VOLUME IV. NUMBER 6

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR

C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS

W. F. KING
Chief Astronomer
Ottawa

R. F. STUPART
Director of the Meteorological Service of Canada, Toronto

J. S. PLASKETT
Dominion Observatory
Ottawa

PUBLISHED BI-MONTHLY

NOVEMBER-DECEMBER, 1910

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.
FOREIGN AGENTS: WILLIAM WESLEY & SON,
28 ESSEX ST., STRAND, LONDON.

THE JOURNAL

OF THE

ROYAL ASTRONOMICAL SOCIETY

OF CANADA

VOL. IV. NOVEMBER-DECEMBER, 1910. No. 6

Our Earth in the Universe	*Otto Klotz*	427
Double Star Measures	*R. M. Motherwell*	447
The Elements of 93 Leonis	*J. B. Cannon*	452
The Spectroscopic Binary ε Ursæ Minoris	*J. S. Plaskett*	460
Meetings of the Society		
At Toronto	*L. G.*	466
At Ottawa	*C. E.*	469
At Hamilton	*T. H. W.*	471
At Peterborough	*H. B. C.*	473
At Winnipeg, Manitoba	*C. V. S.*	478
Notes from the Dominion Observatory		
Terrestrial Magnetism	*O. K.*	480
The Seismograph	*O. K.*	482
Notes from the Meteorological Service		
Report of the Weather in Canada, October-November	*R. F. S.*	483
Magnetic Observations		486
Earthquake Records at Toronto and at Victoria, B. C.	*J. Y.*	487
Book Reviews	*ð.*	488
Astronomical Notes		
At the International Solar Union—Study on Solar Radiation		489
Spectra of Sun-Spots		489
The Distances of the Red Stars		490
Regarding the Discovery of Comets		490
Aristarchus		491
The Tidal Observations of the British Antarctic Expedition, 1907		491
A Projection on Saturn's Outer Ring		492
Meteorology in Japan		492
The Average Uniformity of Certain Markings on Jupiter	*J. R. C.*	493
Notes and Queries	*C. A. C.*	494
Predictions for January and February	*C. A. C.*	497
Library Catalogue	*A. Sinclair*	1
List of Lantern Slides	*R. S. Duncan*	32
Index to Volume IV.		

Editorial communications should be addressed to C. A. Chant, University of Toronto, Toronto, Ont.

Business correspondence, remittances, etc., should be addressed to Chas. P. Sparling, Treasurer of the Society, 315 East Roxborough St., Rosedale, Toronto.

Communications regarding Library matters should be addressed to the Librarian.

$2.00 per annum. Single numbers, 35 cents.

Subscription to the *Journal* is included in membership fee.

Anyone wishing to purchase a Telescope may correspond with the Secretary, Toronto.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

OFFICERS FOR 1910

Honorary President—W. F. KING, C.M.G., LL.D., Chief Astronomer, Ottawa.
President—Professor ALFRED T. DE LURY.
First Vice-President—Professor LOUIS B. STEWART
Second Vice-Presdent—J. S. PLASKETT, B.A.
Secretary—J. R. COLLINS.
Treasurer—CHAS. P. SPARLING.
Recorder—MISS ELSIE A. DENT.
Librarian—A. SINCLAIR, M.A.
Curator—ROBERT S. DUNCAN.

Council—The above Officers and the following members:—JOSEPH POPE, C.M.G., Ottawa; REV. D. B. MARSH, D.Sc., F.R.A.S., Peterborough; Rev. I. J. KAVANAGH, S.J., D.Sc., Montreal; WM. BRUCE, Hamilton; LACHLAN GILCHRIST, M.A., Toronto; R. M. STEWART, M.A., Ottawa; and Past Presidents ANDREW ELVINS, JOHN A. PATERSON, K.C., M.A., R. F. STUPART, F.R.S.C., Professor C. A. CHANT, W. BALFOUR MUSSON; and the presiding officer at each Centre as follows: DR. OTTO KLOTZ, H. B. COLLIER, B.A., and G. PARRY JENKINS, F.R.A.S.

OTTAWA CENTRE

Local President—OTTO KLOTZ, LL.D., F.R.A.S.
Vice-President—J. S. PLASKETT, B.A.
Secretary—CARL ENGLER, B.A.
Treasurer—C. C. SMITH, B.A.
Council—R. M. STEWART, M.A., F. A. MCDIARMID, B.A., J. J. MCARTHUR, D.L.S.

PETERBOROUGH CENTRE

Local President—H. B. COLLIER, B.A.
Vice-President—H. O. FISK
Secretary-Treasurer—REV. DR. MARSH, D.Sc., F.R.A.S.
Council—T. A. S. HAY and D. E. EASON, B.A.Sc.

HAMILTON CENTRE

Local President—G. PARRY JENKINS, F.R.A.S.
First Vice-President—WILLIAM BRUCE.
Second Vice-President—E. H. DARLING, A.M.C.S., C.E.
Secretary—T. H. WINGHAM, B.A.Sc.
Treasurer—A. T. NEILL.
Council—REV. R. E. M. BRADY, D.Sc., W. A. ROBINSON, REV. J. J. MORTON.

PLATE XXXV.

THE TETRAHEDRAL EARTH

Journal of the Royal Astronomical Society of Canada, 1910

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR

C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS

W. F. KING
Chief Astronomer
Ottawa

R. F. STUPART
Director of the Meteorological Service of Canada, Toronto

J. S. PLASKETT
Dominion Observatory
Ottawa

VOLUME IV., 1910

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.
FOREIGN AGENTS: WILLIAM WESLEY & SON,
28 ESSEX ST., STRAND, LONDON.

CONTENTS OF VOLUME IV.

I. JANUARY–FEBRUARY.

Recent Discussion in Astronomy and Astrophysics — *W. Balfour Musson* — 1

Scientific Crumbs from Europe — *Otto Klotz* — 21

Meetings of the Society at Toronto, 35; at Ottawa, 42; at Peterborough, 48; at Hamilton, 49. Notes from the Dominion Observatory, 53. Notes from the Meteorological Service, 59. Book Reviews, 65. Astronomical Notes, 66. Predictions for March and April, 71.

II. MARCH–APRIL.

Photographs of Jupiter — *Percival Lowell* — 81

A Least Square Solution of the Orbital Elements of α Draconis — *W. E. Harper* — 91

Personality with the Transit Micrometer — *R. M. Stewart* — 94

Halley's Comet — *C. A. Chant* — 104

The Seismograph — *Otto Klotz* — 116

Meetings of the Society at Toronto, 130; at Ottawa, 132; at Hamilton, 137; at Peterborough, 141. Notes from the Dominion Observatory, 143. Notes from the Meteorological Service, 148. Astronomical Notes, 154. Notes and Queries, 159. Predictions for May and June, 164.

III. MAY–JUNE.

Earthquake Epicentres — *Otto Klotz* — 173

The Location of the Pole — *L. B. Stewart* — 179

The Orbit of η Boötis — *W. E. Harper* — 191

The Orbit of φ Persei — *J. B. Cannon* — 195

A Laymen's Diary of Halley's Comet, 1910 — *A. F. Hunter* — 204

Water Vapor on Mars — *W. W. Campbell* — 212

Meetings of the Society at Toronto, 214; at Ottawa, 215; at Hamilton, 219. Notes from the Dominion Observatory, 222. Notes from the Meteorological Service, 229, Astronomical Notes, 234. Notes and Queries, 237. Predictions for July and August, 244.

IV. JULY-AUGUST.

Sir William Huggins, K.C.B., O.M. - - *C. A. Chant* 253
Some Interesting Binary Stars - - *J. Miller Barr* 261
A Modified Method of Nadir Observations - *R. M. Stewart* 267
Olbers: the Greatest of Amateur Astronomers - *Albert D. Watson* 271
Art and Astronomy - - - *John A. Paterson* 282
Meeting of the Society at Hamilton, 299. Notes from the Dominion Observatory, 300. Notes from the Meteorological Service, 305. Astronomical Notes, 309. Notes and Queries, 317. Predictions for September and October, 321.

V. SEPTEMBER-OCTOBER.

Slit Widths and Errors of Measurement in Radial Velocity Determinations - - - *J. S. Plaskett* 333
Stellar Magnitudes - - - *J. E. Maybee* 345
Some Preliminary Results Deduced from Observed Radial Velocities of Stars - - - *W. W. Campbell* 353
The Mount Wilson Conference of the Solar Union *C. A. Chant* 356
The Astronomical and Astrophysical Society of America *J. S. Plaskett* 373
Johann Gottfried Galle - - - *C. A. Chant* 379
Meetings of the Society at Toronto, 386; at Ottawa, 388; at Hamilton, 390; at Regina, Saskatchewan, 391. Notes from the Dominion Observatory, 394. Notes from the Meteorological Service, 400. Book Reviews, 407. Astronomical Notes, 409. Notes and Queries, 410. Predictions for November and December, 416.

VI. NOVEMBER-DECEMBER.

Our Earth in the Universe - - - *Otto Klotz* 427
Double Star Measures - - - *R. M. Motherwell* 447
The Elements of 93 Leonis - - - *J. B. Cannon* 452
The Spectroscopic Binary ϵ Ursæ Minoris - *J. S. Plaskett* 460
Meetings of the Society at Toronto, 466; at Ottawa, 469; at Hamilton, 471; at Peterborough, 473; at Winnipeg, Manitoba, 478. Notes from the Dominion Observatory, 480. Notes from the Meteorological Service, 483. Book Reviews, 488. Astronomical Notes, 489. Notes and Queries, 494. Predictions for January and February, 497. Appendix: Library Catalogue, 1; List of Lantern Slides, 32. Index.

THE JOURNAL
OF THE
ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOL. IV. NOVEMBER-DECEMBER, 1910. No. 6

OUR EARTH IN THE UNIVERSE*

BY OTTO KLOTZ

STANDING on our earth and looking out into the universe on a cloudless night, the thinking man can not but help be absorbed in thought. He a sentient being, surrounded by animate and inanimate matter, beholding the many, many shining orbs in the heavens. Let me correct right here a popular belief that the number of stars visible to the naked eye is not tens of thousands or millions as is often supposed, but only about 3,000. Of course with a telescope, which is only a cyclopean eye, we can see very many more, the light gathering power of the telescope varying as the square of the diameter of the object glass, so that our Observatory telescope which has a glass 15 inches in diameter gathers theoretically 225 times as much light as does that on the surveyor's instrument one inch in diameter.

After this short digression let us return to our outlook in the heavens. A flood of thoughts comes over us. What are those orbs; whence come they, whither are they going; is the apparent chaos but a manifestation of our ignorance; are there other worlds than ours, which being dark we cannot see; are

* Address given before the Royal Astronomical Society of Canada at Toronto, November 22, 1910.

there beings on such worlds that feel and think, suffer grief and pain, experience hope and joy; are such worlds covered with vegetation, have they rivers and seas, and do they undergo the changes of seasons; does our earth belong to the same family, does it take its place among the grand army of the heavenly host to complete the harmony of the spheres?

Such are a few of the thoughts that present themselves. Some of them we can answer, some not, and, perhaps, never shall be able to answer definitely.

When we look about us we see constant change going on, a cycle of transitions so well illustrated by the action of the sun on the oceans, where the water rises as vapor, to be condensed into clouds, which in turn fall as rain over the land, where it runs off in creeks and rivers to the parent that gave it birth.

And so it is in the universe. The universe has always been as it now is, only matter, energy and life have changed their form and place in space. All the stars we now see, and they are all incandescent bodies, hotter than any temperature we can produce, will one after another turn bleak and cold, but as they die others will be born of which we have direct astronomical observational evidence. Ever restless, ever changing, yet following immutable laws which we on this tiny earth, this mere dust speck in the great Cosmos, are trying to unravel. The appreciation of the harmony and beauty of the universe is one of the greatest triumphs of the human intellect.

It is a satisfaction to know that our earth is a member of the grand galaxy, that the laws which govern its motion of rotation and revolution are those for all other bodies. We have been looking onto the celestial vault at night; let us turn to the other side and gaze on the face of our parent—the sun—from whom we receive life and nourishment. This parent has a pretty large family of children, some of whom have wandered far from home, while others enjoy more of the warmth due to proximity, like ourselves. And there are some grand-children too, some ruddy and vigorous, but the one we love best is our own daughter, though pale and wan. The date and circumstances of the birth

of these children and grand-children is unknown; we have only surmises. Perhaps our parent is only a foster-mother, if so, none could be more beneficent and kind, yet ruling us with unswerving hand.

A fairly safe assumption we may make, however, is that at a very early stage of our earth's being, it was a molten mass rotating on an axis and revolving about the sun. Every hot body radiates heat and thereby eventually cools, and this means contraction in general. Now what must happen if a sphere contracts? Evidently the given mass is trying to occupy less volume. If the particles are capable of crowding closer together, the sphericity might be maintained, but if not, there will be rupture or deformation of some kind. It is held by some able geophysicists, and with much plausibility that the tendency of the contracting earth is that the stresses and strains set up would follow the lines of least resistance, and this tendency would be for the surface of the earth to maintain itself, resulting in the spherical form of the earth being changed, if not to, but, towards the tetrahedal or tetrahoidal form. The tetrahedron is one of the regular geometrical solids which has the least volume for a given surface.

As you see from this model (Plate XXXV.) this would mean that the earth would tend to have four corners, six edges and four surfaces, the edges manifesting themselves as mountains, and the surfaces as depressions and hence oceans. Although we know that the earth doesn't look like this tetrahedron, yet there are features about the earth that do favor the tetrahedral theory. Let us take the poles. We know that the south pole is surrounded by land, which corresponds to an apex of the tetrahedron, opposite to it is a surface, equivalent to a depression or ocean as we actually find to be the case at the north pole, if we may believe some of the discovers.

In the tetrahedron every corner has a surface opposite to it, so that for the earth this would mean that land and water are antipodal, which is fairly well represented in the actual conditions. Another result would be that the land masses would be

broad in the northern hemisphere and taper towards the south, which too agrees with our geography. Inversely, the oceans should contract towards the north, a condition fairly well borne out. The north polar sea being represented by a surface of the tetrahoidal figure, and the south polar one by a corner, it would follow that the flattening of the earth in the southern hemisphere would be less than in the northern, and furthermore that the force of gravity would increase less rapidly towards the south pole than towards the north pole. Both these considerations have been confirmed by geodetic and pendulum observations.

We will take then the hardened surface of the earth, whether shaped by the tetrahedral theory or simply as fortuitously crushed by contraction, throwing up our mountain chains, and giving us our geography practically as we find it to-day. After millions of years of cooling, the most important chemical action is the production of water vapor, and with its advent the real era of the earth may be said to begin. How the first germs of vegetation originated we know not. However data are available by means of which the advent of life upon the earth may be explained. Up to within comparatively recent years it was considered impossible for small particles to become irrevocably detached from the parent body on account of gravitation. A force, however, although very small in magnitude, has been discovered in light, known as light pressure, which operates in opposition to gravity. The force of gravity is dependent upon mass and acceleration, and mass is dependent upon volume and density. Volume has three dimensions hence the force of gravity varies as the cube of the linear dimensions of the particle. Light pressure, which exerts its action by pushing we may say, varies as the surface of the particle, that is as the square of the linear dimensions. It is obvious, therefore, however preponderant gravity may be over light pressure on a large particle, if we keep on reducing the latter in size light pressure continues to gain relatively to gravity until we reach a limit when the push of light pressure will equal the pull of gravity; and when the dimensions are less than this limit, the light pressure will push the particle into space never

to return. This discovery marks a most important epoch in the physics of the universe, furnishing us material among other problems for the discussion of the absorption of light in interstellar space. We cannot here enter into the details of the question of light pressure. Suffice it to say that when particles of spherical form are reduced to a diameter of ·00016 mm., or a sixth of a micron, which is equivalent to 1/150,000 of an inch, light pressure will push such a particle into space. Next we would enquire whether we have on the earth such minute living organisms ; and it is found that the spores of some bacteria are of this order of minuteness. In our investigation we have then arrived at that stage where we have shown the possibility of particles being scattered throughout space through the influence of light pressure.

We have next to find and determine whether such life-bearing particles could pass through the frozen depths of the ethereal solitude without losing vitality. This too has experimentally been shown to be possible. Micro-organisms have been kept for six months at a temperature of 200°C below zero, and spores of bacteria at a temperature of 252°C below zero without destroying their vitality. So that now we arrive at the momentous conclusion that it is possible for life to be transported from one planet to another, from one world to another. Hence a world in its beginning, as ours passed through, may and probably received its first germ of life from some other world. We in turn may contribute for the beginning of life on some world unknown to us. Such a particle leaving the earth under the most favorable conditions would cross the orbit of Mars in 20 days, that of Jupiter in 80 days, that of Neptune in 14 months, and would reach the nearest star — Alpha Centauri — in 9000 years.

With the advent of life upon our earth and its subsequent evolution in so many ways and forms, together with the action of the elements during æons that baffle our comprehension, we will take a view of our planet, as we find it and study its nature and character as well as some of the phenomena that appear upon it.

Lord Kelvin once said that the progress of science was characterised by the refinement of measurements. This is a very terse and accurate definition of the spirit of science to-day.

One of the first questions that presents itself in the study of our earth is its size, its dimensions, and what relation such bear to other bodies, be they planets or suns. We shall attempt to measure the earth then. But what is our measuring stick or tape-line? We find none ready made, we shall have to invent one. The crude barley-corn, or span, or hand, or ell, or the King's foot are too crude to entertain. However we can take a stick, put some fine marks near the ends and call the distance between them by some name, say yard, and use this as a unit. This is what actually has been done, and to legalise such measure an act of Parliament is necessary. By 42 Victoria, c. 16, s. 4, the Dominion linear standard is the yard as represented by a certain bronze bar deposited at the Department of Inland Revenue. Over a hundred years ago the French Academy of Sciences conceived the apparently scientific idea of using the earth itself as a unit of measure, and to this end it was decreed that the ten millionth of the quadrant of the earth, that is the distance from the equator to either pole be a metre. The idea too was that at any time and at any place the length of the unit could be determined. This is, however, not the case, and the actual standard prototype metre in France, from which international duplicates have been made, is a metallic bar.

Having now adopted some unit of measure let us see how we may measure the size of the earth. Let us do it in the simplest way. Suppose we go to the western provinces where there is little obstruction for measuring. Let us measure along the division line between Alberta and Saskatchewan, which runs due north, beginning at the International Boundary or 49th parallel. Supposing we measure exactly 400 miles; this would bring us about half way towards the north limit of these provinces. We have now a measured straight line on the earth running due north and south. Now we all know that the angle between the equator and the pole at the centre of the earth is a

right angle or 90°, *i. e.*, the quarter circumference of the earth is represented by 90°, and any fractional part of the quadrant by the corresponding fraction of 90°. We will, therefore, set up a suitable instrument at each end of our measured line and observe the elevation of say the pole star on the meridian. The difference of the elevations found will be the angle at the centre of the earth between the two points, *i. e.*, we know now that the fractional part this angle is of 90°, and hence the fractional part that our measured line is of the quadrant. Hence we know the circumference and diameter of the earth. We can now reach out to our neighbors — being those of the solar system — and use for our yardstick, the diameter of the earth, being nearly 8000 miles, and by trigonometrical methods find out how far they are away and their size. The sun is found to be nearly 93,000,000 miles distant, a distance that the mind cannot really picture. But we are not yet at the end of our sounding line. We penetrate still farther, we plunge beyond the confines of our solar system, and find that we will again have to change the length of our yardstick to make it at all comparable to the distances we have to measure. This time we take the above distance to the sun as our unit, but instead of expressing it in miles, we will express it in light-years.

We know that light takes time to travel from its source through space. To come from the sun takes about 8⅓ minutes, *i.e.*, 93,000,000 miles are covered in that time, and in a year it will travel 63,000 time as far. In our mad rush through space at the rate of 186,000 miles a second we will reach the nearest stellar system, with a sun like our own, in somewhat over four years. For more remote stars a thousand or more years may be necessary. The mind cannot realise infinity, yet astronomy deals in appalling magnitudes of distance, initially projected from this tiny earth by a little grey matter enclosed within a bony shell possessed by an atom called — Man.

Let us hurry back from cheerless space and again tread our own *terra firma*, basking in the sun-shine and enjoying its warm glow. Having already wandered about the earth, we found fossils that told us in unmistakeable words of former life, both

animal and vegetable, and we find them in regions where now it would be impossible for them to flourish on account of the cold ; for instance, coal and tropical plants like palms in the polar regions. The facts are unequivocal, but what are the reasons? Were those regions at one time nearer the equator, that is, that the axis of the earth was pointing in a different direction, or were we at one time nearer to the sun, conditions that might explain the phenomenon. On the other hand we know that a great part of the northern and southern hemispheres was at one time covered by a thick ice-sheet, a condition the reverse of the other just stated. To what vicissitudes was the earth subjected to produce such vast and radical changes?

It is easy to formulate a theory to fit any particular phenomenon, but to substantiate and prove it, is quite another story.

Astronomy has definitely ruled certain theories out of court, and has shown that such changes can not be attributed to a change in the direction of the axis of the earth upon which depend our seasonal changes, nor to a change of eccentricity of our orbit about the sun. Some other explanation must be sought. The sun, of course, is the governing factor, it is a question of heat.

Let us take a bundle of rays from the sun and examine them. We will find it to be a most beautiful and wonderful collection, permitting of being arranged like organ pipes for the hundreds of different kinds of wave-lengths, each having its own peculiar property as we interpret it. We recognise and treat generally three large divisions, those rays that give us essentially heat, those that produce the sensation of light, and those that manifest themselves most by their chemical action as shown by the photographic plate. At the moment we are most interested in those that give us heat. Next let us try and find out what measure of heat the sun is sending to us. Immediately two considerations present themselves — that of absorption and that of radiation, that is, our receiving device must be such that we catch and retain all the heat rays that fall upon it. For this purpose we use, therefore, a black surface of given dimensions and expose it

at right angles or normal to the rays of the sun to measure how much heat is absorbed. But here a factor comes into play that that must not be overlooked. Those rays from the sun before reaching us pass through our atmosphere, a factor in the life upon our earth that cannot be overestimated. The heat of the surface of the earth is a matter of absorption and radiation. Of the former fully three-fourths is obtained from the wave-lengths that lie between the violet ($\cdot 4\,\mu$) and the ultra-red ($1\cdot 1\,\mu$) of the solar spectrum, while the radiation is by comparatively long wave-lengths, the maximum intensity being in the neighborhood $12\,\mu$. Although of a hot and a cold body we readily say, that relative to each other the hot body radiates and the cold body absorbs heat, but the ultimate mechanism between absorption and radiation is not known. It is obvious that the solar rays in passing through our atmosphere must suffer some absorption, and selective absorption at that, dependent upon the thickness of the layer, upon its temperature, density and gaseous constitution. The last is the point to which we shall give a little consideration in order to offer a plausible explanation, at least, of the varying thermal conditions which we know have obtained on the surface of the earth in order to produce those geological epochs as shown by a tropical fauna and flora in high latitudes, as also by glacial deposits.

At present the composition of the atmosphere is made up mainly of nitrogen and oxygen, there being in volume nearly four times as much of the former as of the latter.

There are traces of other gases besides. Carbonic acid gas or carbon di-oxide which plays so important a part in the earth's history is represented by about ·03 volume per cent. It must appear obvious, that with the continual changes going on on the earth, the weathering and disintegration of rocks, the deposition of calcareous and other matter at the bottom of the ocean to form new geological beds, the continual cycle of life and death in the animal and vegetable kingdoms, all drawing on the vast reservoir of the atmosphere, there must occur some changes in the relative constitution of our atmosphere and these latter

would necessarily by selective absorption modify to some degree the heat of the surface of the earth. From investigation it appears that a slight change in the quantity of carbonic acid gas in the atmosphere would materially affect the climate, an increase would raise the temperature, and a decrease lower it. For instance, it has been computed that an increase from ·03 to ·09 per cent. would raise the the temperature from 12° to 16°F. Such a general rise would have far-reaching results, results that would be of a magnitude quite competent to account for the phenomena we are trying to explain. But the question arises, even if we grant the effect of an increase of carbon di-oxide, how could an increase of this gas be produced? Now, it is well known that the active volcanoes emit vast quantities of aqueous vapor and carbonic acid gas. Here then we have a factor that may give us the desired data, provided evidence can be adduced that there has been sufficient variability in volcanic activity. When we look over the various geological epochs of the earth's history and their accompanying formations, which are to a great extent a matter of chemical combinations, and the latter are largely dependent upon temperature, it is found that volcanic activity has been variable. From this then we seem to be justified in believing that the surface heat of the earth has suffered changes through the varying quantity of carbon di-oxide present in the atmosphere, and a change sufficient to produce those long period climatic changes that certainly have existed on our earth, and which have left such indelible evidences of their presence at one time. Granting the modifying heat effects of carbonic acid gas, we may take into consideration the work of man. I allude to the consumption of coal. Two processes take place, for combustion oxygen is withdrawn from the atmosphere and carbon di-oxide is added, the latter stimulating plant-assimilation besides raising the general temperature as we have seen above, and the former assisting in the restoration of the equilibrium of the oxygen in the atmosphere, as we know that plants in general exhale oxygen. So that the depletion of our coal-beds is not an unmixed evil, and it might be added that the smouldering of our

coal deposits which has been going on for a long time in the Mackenzie basin may mitigate the climate there to an appreciable degree. These deductions are qualitatively sound, and they may be so quantitatively.

Before leaving this subject of solar radiation and absorption it may be stated that the most recent researches on this subject give for what is known as the solar constant about 2 calories, *i. e.*, the direct rays of the sun, after allowing for atmospheric selective absorption, would heat a gramme of water 2°C. in one minute.

Let us now turn our thoughts in another direction. We have shown the place our earth occupies in our own solar system, we have measured its size, we have spoken of life thereon and the vicissitudes it underwent through long geological epochs, now let us turn to a few of the many phenomena that present themselves, for in a brief address one can only touch on so little.

When vacation time comes many of you will go to the woods, camping and hunting, others to streams and lakes, boating and yachting. I think I am safe in saying that, at least, one member in every party will be provided with an almost indispensable article for such expeditions—I mean a pocket-compass. What a valuable little friend it is, provided you don't forget which end means north. In rain or fog or sunshine his tiny finger points to the north, or more accurately to the magnetic north of which we shall presently speak. Oh, what hidden secrets are bound up in that little bit of magnetised steel; perhaps, if it could speak it would tell us that it simply obeys a superior force and places itself in line with it, but of the parentage of the directing officer it is silent, whence its directive power it knows not. It will tell you that it is not as constant as the pole-star, that it does not point in the same direction at different places; for instance, across Canada it changes its direction between Labrador and the Pacific Coast 60°, or ⅔ of a right angle, so that if we wanted to travel any distance with it as guide we should want to know how much it deviates from true north, for its direction of pointing we call the magnetic north. At present at Toronto it points about 6°

west of true north, and in the vicinity of Lake Nipigon it corresponds to the astronomical meridian, while west of that it points to the east of north. Such are the conditions to-day, but there is a slow change from year to year, increasing the deviation in one place and decreasing in another. Furthermore, it makes an oscillation backwards and forwards every day. True as our little friend is, he has his idiosyncrasies and vagaries that keep investigators of terrestrial magnetism busy trying to unravel and explain. In those investigations we once more prove ourselves to be sun-worshippers, something like the Aztecs of the days of Montezuma.

As we watch from day to day and year to year the manifestations and activity of the parent body—the sun—and compare them with the behavior of our magnetic needle we find an undoubted close relationship, but just how the pulsations and throbbings of the sun are sent to us and in what form to affect the needle, or more broadly, terrestrial magnetism we know not; we may surmise however.

I should mention that our magnetic needle, if free to move about a horizontal axis, will also assume another definite direction, the north end pointing downwards as if to some hidden treasure. This deflection from the horizontal we call "dip." You know the sun is a very active and hot body, its mass being in a constant state of turmoil, and boiling and upheaval, which we see as sun-spots and whirls upon its surface. Last year in September the solar cauldron was particularly agitated, and promptly all magnetic instruments in all parts of the world were thrown into a great state of excitement, greater than had happened for a great many years. But the messenger that brought about this reciprocity could not be apprehended. Before reaching the earth, however, he illumined the higher regions of our atmosphere and gave a grand display of that fascinating, that filmy, that fickle, that mysterious light—the Aurora Borealis. This is, undoubtedly, an electrical phenomenon and it is supposed that it is produced by negatively charged particles or electrons shot out by the sun from the particularly disturbed part of its surface.

Of course not all solar outbursts hit the earth, the radiating stream must be in the direction of the earth, and bearing in mind that of the surface of the sphere about the sun at the distance of the earth, the earth covers a very minute part, only about the twenty-one hundred millionth part, you see the chance of being hit by any particular rays is rather small.

An interesting conclusion has been drawn on the basis that the aurora borealis is due to these negatively charged electrons. Such electrons are a product of disintegration, of solar disintegration, that is of solar energy, and measures have been made of this disintegration, with the result that a solar constant has been obtained fairly accordant with the one spoken of, and obtained from solar heat radiation.

To revert to terrestrial magnetism, its practical importance to man need only be stated in order to be recognised. Columbus would scarcely have ventured on the trackless ocean had he not known and made use of the directive action of the magnetic needle. Navigation would be almost impossible if the captain had not the compass to rely upon. When you are crossing the Atlantic, lying snugly in your berth, lulled to sleep, perhaps, by the throbbing of the engines and perhaps not, you feel quite safe and sure that you will arrive at your destination,—why—well because, you will say, its their business to do so. How it is possible to do so, doesn't bother you. However it is mainly due to that mysterious force that keeps the magnetic needle in a certain direction, whereby the captain can guide his course to the desired goal. Let me give just one more practical application, and that is with reference to the surveys in Canada in the early days, when a dense forest covered our lands, and the parcelling into lots and farms had to be done in a cheap and expeditious manner. Under such conditions the compass rendered invaluable service, although it finds no place when accurate work is required. Enough has been said about terrestrial magnetism to show that it has a very direct bearing on thoroughly practical and essential affairs of the world, and hence, deserving continuous observation and investigation for increasing our knowledge of

the laws that govern it. Magnetic and electrical phenomena are closely and intimately allied, so that it is fitting, after speaking of terrestrial magnetism, to say a word about atmospheric electricity, the principal manifestation thereof being lightning, a phenomenon that must have arrested the attention of man from the very beginning of his appearance upon the earth.

Up to the time of the introduction of electrical apparatus about 150 years ago, lightning was believed to be an explosion of some inflammable gases in the atmosphere. Franklin and others proved it to be an electric discharge, and we are not much farther to-day regarding its true nature ; just how it is brought about, how the vapor or gaseous molecules of the air become charged, how and why positively or negatively, whether we have rapid or slow oscillations, why the different kinds of lightning, as chain, forked, sheet and ball lightning. And with reference to the distribution of lightning over the earth, we are considerably in ignorance in explaining, why for instance on the Pacific Coast it is rather a rare phenomenon, while in the East we are frequently startled by its violence. In California where they are accustomed to more or less frequent small earthquakes and have thereby become somewhat callous and indifferent to them, they become alarmed and frightened at a stroke of lightning, because it is so rare.

Granting the presence of atmospheric electricity, it is found on the surface of the minute drops of water floating in the air. When these coalesce to larger drops, it is obvious that the difference of potential will be increased, and the condition favorable for a breakdown or lightning increased. Inversely also if those tiny drops are converted into snow crystals, the electricity is spread out over a greater surface and the condition favorable to lightning decreased.

This explains why in winter we have no thunderstorms unless mild weather sets in.

When a breakdown does occur, that is, when we have a stroke of lightning the air along its path is suddenly heated with explosive effect, which we recognise as thunder. This heated

path becomes now more or less of a conductor and other discharges are apt to follow this path. We see then, that the noise of thunder is not due to a collapse of the air upon itself into a partial vacuum, or reverberation or echoes, but simply due to the different times in which the explosive effect of the sudden heating of the air along the paths reaches the observer. If the lightning is very much forked, the greater will be the roll and rumbling of the thunder. Hence the phenomenon and intensity of thunder are dependent upon the direction and length of the path of the lightning with reference to the observer.

It is frequently observed that a heavy downpour of large drops follows a strong flash of lightning, the former being generally attributed as due to the latter. But the reverse is really the case. The electric discharge between these large drops and the earth takes place but a short distance, a hundred feet or so from the ground, hence the lightning which is practically instantaneous precedes the rain by a few seconds while the drops are falling through the above distance.

Before leaving this subject let me say a word about lightning rods.

A lightning rod is a thoroughly scientific apparatus, but its efficiency depends on its proper installation, above all that it terminate at a sufficient depth in the ground to make good connection therewith, *i.e.*, that it end in moist or wet ground, or the water of a well. All forces follow the line of least resistance, and so does lightning, which is merely a release of the tension between the electricity of the air and of the earth. The human body being a better conductor than the trunk, especially when dry, of a tree, shows the danger of standing under or beside a tall tree during a thunder storm. In cities on account of the many metallic connections between the air and ground the danger from buildings being struck is less than in the country.

We have explored the upper regions of the earth, the atmosphere, and have noted some phenomena there, we have also wandered about the surface, made some measurements and have taken notes from which we have drawn certain conclusions; let

us now do as the boy does when he gets his first watch. find out what there is inside. To dig down into the earth to a satisfactory depth is impossible, for our greatest efforts have only reached a depth of about 2 km. or a little over a mile of the 4000 miles to the centre. Hence we must employ some other means to solve the riddle.

Imagine yourself projected into space in the plane of the equator and then looking at the earth with a telescope. We would notice that it wasn't quite round, but slightly flattened at the poles. We would naturally ask ourselves why is it flattened, and why is it flattened just so much. Two things will occur to us as contributory to the figure of the earth, the one, the fact that the earth rotates on its axis producing a centrifugal force which is most effective at the equator; the other, the distribution of the matter throughout the Earth. The time of rotation of the earth we know exactly, but for the present we know nothing of the distribution, but we can make an assumption in order to have the necessary data for making the computation of what the flattening would be. If we treat the earth as a homogeneous fluid and rotating once in the 24 hours, we shall find that the flattening ought to be $\frac{1}{230}$, but the flattening that we observed was $\frac{1}{298}$ about, so, our assumption of conditions similar to a homogeneous liquid sphere is not quite right. If we make the assumption that the most of the mass, *i. e.*, that the bulk of the gravitational attracting matter is near the centre of the earth, then our flattening turns out to be about $\frac{1}{579}$. We see then that the actual flattening falls between the values found from our two assumptions, so that the truth must lie between them.

While we are out in space we cannot but note the monthly revolution of the moon about the earth. Reflection will tell us that its orbit and time of revolution is not only dependent upon the mass of the earth but also upon its distribution, which involves the shape or figure of the earth, and hence its flattening. From these lunar observations we can deduce the flattening to be

$\frac{1}{230}$, agreeing with what we actually found by direct observation when looking at the earth from space. So far so good.

Many of you have been at the sea-shore or at some of the summer-resorts along the lower St. Lawrence and have, therefore, witnessed the tides — the breathing of the sea, as it has been called,—the sight of which for the first time is always certain to arouse wonder. We wander about on a sandy beach and but a few hours afterwards there are probably many feet of water there. This oscillation continues day by day and week by week without fail. What causes this mysterious daily ebbing and flowing of the waters? It is the moon and the sun, principally the former, that are responsible for them by the law of gravitation. We cannot here enter into any details about the tides, but the reason they are referred to is that they tell us something of the constitution of the earth, something about its solidity and resistance to deformation, for it is plain if the earth yielded as readily to the pull or attraction by the moon as does the water, then there would be no tides, for land and water would move together and there would be no relative rise of the water above the land. Now it can be computed, knowing the mass and distance of the moon, just how much the water should rise provided the earth is absolutely rigid. The comparison between the computed result and the observed one, which is smaller, gives then the amount of yielding of the earth, and from this amount of yielding the degree of rigidity of the earth is found, being about that of steel. Very recently direct observations have been made of the actual tides that the earth's solid surface or crust undergoes, with the result that we find that when the full moon rides high in the heavens we are raised from 4 to 6 inches above where we were at the rising or setting of the moon. From the tides then we have learned that the earth is not such an absolutely solid body as one might be inclined to believe.

It is not many years ago, and you all remember it, when the world was startled by the discovery of the X or Röntgen rays by means of which we can find out the contents of boxes or parcels

without opening them, simply by getting a photographic impression by the X rays after passing through our Pandora's box.

If instead of our box we substitute the earth, and ask, say, some of our friends in the other Dominion of the British Empire—New Zealand, which is almost antipodal to us — to send us some Röntgen rays that we might catch them on a plate. Wouldn't that tell us something of the interior of the earth, at least, how pervious or impervious it was to that particular kind of rays? But for our purpose we can send a better messenger through the earth than one mounted on X rays, although he will travel not quite so fast.

I refer to the pulsations set up by strong and severe earthquakes, like those of San Francisco and Messina, that set the earth trembling from Pole to Pole. There was not a square foot of the earth's surface that was not set into vibration by each of those earthquakes. It is unnecessary to state that both those were recorded here and at Ottawa, as is every large earthquake, no matter how far distant.

At the beginning of last year we had a fine record at Ottawa of a destructive earthquake in Persia, some 6000 miles away. If you were to examine a number of our records or seismograms, as we call them, you would see certain characteristics common to them all, which you would be told are due to the different kinds of pulsations or waves that issue from the earthquake centre. If we know the place and time that an earthquake happened, as is the case with San Francisco, Messina and others, and our own record gives us the time of arrival here of the different kinds of waves, of which we recognise particularly three, viz: the longitudinal waves which are the first to arrive, then come the transverse waves and the last to arrive are the surface waves, then we know how long each took to get here.

It is obvious that the messengers that bring these various records must be influenced by the path which they have to follow, just as a railroad with easy grades and few curves will be able to make better time than if not so favored. We know that when the earth quaked in Persia last January particles there were set

in vibration, they communicated that vibration to others and so on until the vibrations reached Ottawa and communicated them to our instrument or seismograph — while we were all perfectly oblivious of the slightest or minutest movement. If the substance between Persia and Ottawa were like putty, do you think we would have had any record? Certainly not. You all know that the rapidity with which pulsations are transmitted through different substances depends upon their nature, their density, their elasticity. You must admit then that these wave messngers each tells his story of the kind of path he followed in order to arrive at a certain time.

Bearing in mind that each earthquake sends out three chief messengers in all directions, when we compare their records, Marathon records so to speak, we shall find that one of them always keeps the same pace whether he has to run far or not. His path lies along the surface, and he jogs steadily along at about 125 miles a minute, while his two companions not only have a faster gait, but the farther they have to go the faster they run, and the reason for this is that they dip down into the earth where they find a faster route. In short, the vibrations are transmitted at a greater speed at greater depths up to a certain limit.

Let me put it in another way, it took the first preliminary tremors or longitudinal waves from the San Francisco quake relatively longer to reach here than from Messina, and from the latter relatively longer than from Persia the more distant place, while the time for the surface waves was directly proportional to the distance. The quickest route for the waves first to arrive is not along a straight line through the earth joining the two places, but along a line somewhat curved towards the centre of the earth, for not only is the material denser there, but is also more elastic thereby increasing the speed of transmission.

We have observed so many earthquakes now whose origins were known, with our highly sensitive instruments, and tabulated the times for the various kinds of waves, that we are able to deduce inversely how far an earthquake is or was away as soon

as we have examined our seismogram and noted the difference of times of arrival of the different kinds of waves spoken of.

From the pulsations then that are sent out by earthquakes we have the first and direct evidence of the constitution of the interior of the earth. It is clear it cannot be a liquid, molten mass as was so long believed, for a liquid could certainly not transmit transverse waves. From earthquake records we know that the earth is solid from stem to stern, with some pustules in its skin which we call volcanoes.

Broadly speaking, we have a rocky or stony mantle about 1000 miles thick enclosing a very dense metallic core within.

We in Eastern Canada need have little anxiety about severe or destructive earthquakes; our rocks are too old and pretty well settled. When adjustment of strains does take place, it is along the weakest lines or geological faults as they are called. The biggest one we have of these, lies in the St. Lawrence river from Quebec down to the Gulf. The little shock we had a few weeks ago was nothing, as earthquakes go, yet some people were very much alarmed. Let us be thankful that we are not in an earthquake area.

I have led you about from the depths of space to the depths of the earth. We have spoken of things celestial and terrestrial, of the harmony of nature and the immutable laws by which it is governed. In conclusion let me quote from *Buckle* — "And, as to man himself, what is he but the incarnation of thought? For what constitutes the man is not his bones, nor his flesh, nor his blood. These are the accidents, the encumbrances, the impediments of his nature."

Dominion Observatory,
Ottawa, Canada.

DOUBLE STAR MEASURES

By R. M. Motherwell.

THE measurement of double stars was begun at this Observatory in the summer of 1907. Three half nights a week are devoted to this work but considerable encroachment is made on this time by the photographing and measurement of comets. The 15-inch Equatorial is equipped with a Warner and Swasey filar micrometer, the red illumination being invariably used. The longitudinal wire broke shortly after the beginning of the work and at present there are only two wires, one fixed and one movable, no others being required. A programme has been arranged from Burnham's *General Catalogue of Double Stars*, the aim being to measure only neglected pairs or those whose motion seems uncertain. I am much indebted to Professor Burnham for severable valuable suggestions in connection with the work.

I wish also to express my indebtedness to Dr. King and Mr. Plaskett for the assistance and encouragement they have given me in the carrying out of this programme.

Number	Epoch	Position Angle	Distance	Number	Epoch	Position Angle	Distance
		°	"			°	"
70	1907·814	224·3	17·75	**758**	1907·790	A B 100·1	2·15
	1910·690	224·1	17·32		1907·790	C D 136·2	4·85
Mean	1909·252	224·2	17·53	**1002**	1907·814	162·8	5·88
151	1908·786	279·0	1·34	**1223**	1909·914	288·2	4·71
					1910·701	290·9	5·02
269	1908·765	114·0	5·78		1910·745	291·3	4·79
	1910·701	114·7	5·91	Mean	1910·453	290·1	4·84
	1910·745	113·6	5·69				
Mean	1910 070	114·1	5·79	**1239**	1910 701	261·2	34·02
319	1907·920	11·0	61·07	**1427**	1907·812	315·7	3·07
					1908·921	313·9	3·28
710	1907·920	190·2	30·20	Mean	1908·366	314·8	3·18

Number	Epoch	Position Angle	Distance
		°	″
1655	1909·768	228·7	6·71
1750	1907·920	248·3	17·04
	1908·920	249·1	17·24
Mean	1908·420	248·7	17.14
2040	1907·920	222·6	3·95
	1908·921	218·8	4·21
	1910·067	220·7	4·12
Mean	1908·969	220·7	4·09
2043	1907·812	323·7	4·03
	1910·067	321·8	4·62
Mean	1908·939	322·7	4·32
2536	1908·996	305·3	2·73
	1910·067	299·7	2·85
Mean	1909·531	302·5	2·79
2544	1909·796	27·2	11·89
3334	1910·067	325·2	10·82
3348	1910·067	162·7	6·88
4452	1909·341	43·27	2·60
4491	1910·092	300·4	19·26
4530	1909·086	139·6	6·12
4890	1908·247	196·9	5·14
	1909·086	196·7	4·88
	1909·303	197·0	5·11
Mean	1908·879	196·9	5·04
5011	1908·247	45·5	1·88
5014	1909·202	235·9	3·50
	1909·303	234·0	3·39
	1909·341	235·5	3·40
Mean	1909·282	235·1	3·43
5019	1910·279	302·0	24·99
5125	1908·304	146·5	3·43
	1910·279	146·1	3·56
Mean	1909·291	146·3	3·50
5302	1909·202	293·9	6·08
5319	1908·304	176·9	2·50
	1908·426	177·3	2·78
Mean	1908·365	177·1	2·64
5337	1908·304	293·5	30·09
	1908·426	294·2	29·38
	1908·977	295·2	30·78
	1909·183	294·4	31·50
	1909·202	294·8	31·89
	1909·399	294·3	31·09
Mean	1908·915	294·4	30·79
5388	1908·247	117·4	3·88
	1909·183	114·1	3·89
	1909·399	116·4	3·82
Mean	1908·943	116·0	3·86
5426	1908·247	68·6	3·05
	1909·303	68·1	3·50
	1909·399	66·5	3·27
Mean	1908·983	67·7	3·27
5705	1909·303	32·2	3·37
5809	1908·977	27·6	24·86
	1909·078	28·0	25·17
	1909·202	27·6	24·89
	1909·303	28·3	25·33
Mean	1909·140	27·9	25·06
5892	1910·092	57·5	31·44
	1910·112	57·6	30·72
	1910·188	57·7	31·00
Mean	1910·131	57·6	31·05
6030	1908·426	308·1	2·80
	1910·284	309·5	2·63
Mean	1909·355	308·8	2·72
6033	1908·426	108·8	6·28
	1909·078	107·8	5·72
	1909·202	106·8	6·06
	1909·303	106·8	6·57
	1909·437	106·4	Clouds
	1910·188	105·8	6·58
Mean	1909·272	107·1	6·24
6035	1909·078	178·8	16·32
	1909·086	181·7	16·10
	1909·183	179·3	16·50
	1909·399	179·4	16·41
Mean	1909·187	179·8	16·33

Number	Epoch	Position Angle	Distance
		°	"
6211	1908·371	359·4	1·88
	1908·426	359·2	2·60
	1910·188	0·3	2·17
Mean	1908·995	359·6	2·22
6386	1909·360	119·0	2·99
	1909·494	118·1	3·11
	1910·284	118·7	Clouds
Mean	1909·713	118·6	3·05
6390	1910·188	2·6	7·32
6415	1909·437	345·4	1·85
	1909·494	344·4	2·21
	1910·306	343·7	1·89
Mean	1909·746	344·5	1·98
6599	1909·437	229·6	3·22
	1909·494	230·7	3·45
	1910·216	230·2	3·39
	1910·254	229·6	3·64
Mean	1909·850	230·0	3·43
6614	1910·188	161·8	4·31
	1910·207	159·9	4·15
Mean	1910·198	160·9	4·23
6753	1910·092	213·0	61·74
	1910·207	212·9	64·82
	1910·489	213·4	63·36
Mean	1910·203	213·1	63·31
6780	1909·494	349·8	1·52
7065	1909·494	115·9	4·60
	1910·306	115·5	4·56
	1910·489	114·4	4·62
Mean	1910·096	115·3	4·59
7117	1908·217	305·8	1·88
	1908·309	301·1	1·72
Mean	1908·263	303·5	1·80
7318	1908·217	184·5	3·90
	1908·317	184·3	3·81
	1909·494	184·3	3·60
Mean	1908·676	184·4	3·77
7429·5	1909·429	252·9	9·39
	1909·494	252·9	9·26
	1909·634	254·3	9·46
	1910·216	253·2	9·08
	1910·254	253·4	9·57
Mean	1909·805	253·3	9·35
7450	1908·575	15·2	8·70
	1908·617	14·3	9·20
	1908·631	14·0	9·50
	1909·412	14·9	8·92
	1909·429	13·9	9·18
	1909·437	14·1	9·48
Mean	1909·017	14·4	9·16
7451	1908·317	255·4	16·64
	1908·464	254·1	17·11
	1908·575	254·8	16·57
	1908·617	256·0	16·17
	1908·631	254·6	16·65
Mean	1908·521	255·0	16·63
7458	1908·575	288·9	3·24
7480	1909·634	77 2	83·97
	1910·383	76·9	84·55
Mean	1910·009	77·1	84·26
8364	1908·617	81·6	2·71
	1908·746	78·2	2·87
	1908·765	79·4	2·70
	1909·429	78·2	3·00
Mean	1908·889	79·4	2·82
8384	1908·617	82 0	1·50
	1909·631	79·8	1·60
Mean	1909·124	80·9	1 55
8404	1908·631	338·4	27·15
	1908·641	338·7	27·47
	1908·765	339·3	26·90
Mean	1908·679	338·8	27·17
8431	1910·681	136·0	53·82
	1910·706	136·1	53·72
Mean	1910·694	136·1	53·77
8432	1910·681	62·4	Clouds
	1910·706	62·3	24·50
Mean	1910·694	62·4	24·50
8481	1910·706	70·2	39·43
8504	1910·706	237·5	5·25
9034	1908·541	51·9	7·84
	1908·581	50·5	8·50
	1909·631	50·2	8·11
	1909·763	51·3	8·46
Mean	1909·129	51·0	8·23

Number	Epoch	Position Angle	Distance
		°	″
9037	1908·541	7·4	5·90
	1908·581	7·3	5·88
	1908·641	7·2	5·68
	1908·765	7·1	5·90
Mean	1908·632	7·3	5·84
9107	1910·638	229·9	59·54
	1910·660	229·8	59·47
Mean	1910·649	229·9	59·51
9167	1908·541	154·8	0·84
	1908·613	154·5	0·89
Mean	1908·577	154·7	0·87
9181	1910·638	104·8	6·78
	1910·706	103·1	7·10
Mean	1910·672	104·0	6·94
9183	1910·651	102·5	36·13
	1910·660	102·3	36·45
	1910·668	102·4	36·53
Mean	1910·660	102·4	36·37
B.D. 63°	1501 and	1502:	
	1910·668	156·4	78·66
B.D. 63°	1505 and	1506:	
	1910·638	103·8	24·54
	1910·660	103·3	24·01
	1910·668	103·4	24·76
Mean	1910·655	103·5	24·44
9604	1908·541	9·7	2·81
	1908·613	10·5	2·75
Mean	1908·577	10·1	2·78
9693	1907·530	136·9	3·98
	1908·492	138·6	4·07
	1908·522	138·0	3·74
	1908·581	138·6	4·01
	1908·613	137·8	3·93
Mean	1908·348	138·0	3·95
9905	1908·600	271·1	Clouds
	1909·631	271·7	20·09
	1910·627	270·8	19·37
Mean	1909·619	271·2	19·73

Number	Epoch	Position Angle	Distance
		°	″
9970	1909·686	297·6	8·95
	1909·763	298·5	8·86
	1910·534	298·5	8·71
	1910·627	298·1	8·92
	1910·638	297·6	8·83
Mean	1910·250	298·1	8·85
9977	1908·641	170·1	4·30
	1908·765	171·0	3·84
	1908·786	171·8	3·50
Mean	1808·731	171·0	3·88
9980	1909·763	277·1	4·41
9985	1909·782	134·1	6·39
	1910·580	132·5	5·79
Mean	1910·181	133·3	6·09
10005	1910·627	151·5	23·28
	1910·638	151·4	23·07
	1910·668	151·4	23·56
Mean	1910·644	151·4	23·30
10061	1908·765	185·3	7·18
10064	1910·627	297·5	49·75
	1910·638	297·4	49·79
	1910·668	297·4	49·60
Mean	1910·644	297·4	49·71
10066	1910·690	AD 256·8	32·18
	1910·690	AE 75·8	36·38
10072	1907·576	215·0	0·73
	1908·613	212·2	1·30
Mean	1908·095	213·6	1·02
10075	1910·572	48·8	4·31
	1910·690	49·8	4·51
	1910·701	51·5	4·73
	1910·739	50·3	4·65
Mean	1910·676	50·1	4·53
10385	1907·710	112·7	3·38
	1908·581	111·0	3·51
Mean	1908·146	111·9	3·45
10685	1908·522	164·6	1·89

Number	Epoch	Position Angle	Distance	Number	Epoch	Position Angle	Distance
		°	″			°	″
10709	1907·587	160·2	3·35	**10943**	1910·627	87·7	44·18
	1908·522	163·1	3·34		1910·668	89·2	44·31
	1908·613	158·3	3·39	Mean	1910·648	88·5	44·25
Mean	1908·241	160·5	3·36				
				11021	1910·627	159·7	3·72
10742	1908·613	349·2	22·90		1910·701	159·5	4·06
	1908·765	351·5	23·89		1910·739	159·1	3·89
	1909·686	351·7	23·54	Mean	1910·689	159·4	3·89
	1909·763	352·5	23·54				
Mean	1909·207	351·2	23 47	**11048**	1909·782	183·9	4·23
					1910·690	184·9	3·93
10773	1907·543	307·0	3·50		1910·701	185·8	3·92
	1908·522	309·3	3·37	Mean	1910·391	184·9	4·03
	1908·541	307·9	3·85				
	1908·581	307·5	3·71	**11068**	1907·697	320·0	1·70
	1908·786	307·8	3·44				
	1908·805	308·8	3·18	**11376**	1907·697	27·0	1·85
Mean	1908·463	308·1	3·51				
				11487	1909·763	47·1	17·59
10898	1910·627	270·0	3·93		1910·701	47·0	17·36
					1910·739	46·5	17·14
10901	1908·613	112·6	5·68	Mean	1910·401	46·9	17·36
	1908·641	112·0	5·60				
	1909·782	114·1	5·40	**11499**	1909·763	95·2	19·95
	1909·859	112·0	5·76		1909·782	94·7	20·13
Mean	1909·224	112·9	5·61		1910·668	94·1	Clouds
					1910·690	93·7	18·95
10910	1907·576	106·0	1·59	Mean	1910·226	94·4	19·68
				11501	1909·914	100·0	7·93
10917	1910·580	334·7	13·39				
	1910·701	334·3	13·63	**11546**	1910·745	179·6	11·18
	1910·706	336·6	13·72				
Mean	1910·662	335·2	13·58	**11601**	1910·745	22·1	2·56
10925	1910·660	43·0	4·37	**12230**	1909·782	358·4	33·44
	1910·690	45·2	4·38		1909·914	358·7	33·22
Mean	1910·675	44·1	4·38		1910·668	359·2	32·82
				Mean	1910·121	358·8	33·16
10934	1910·627	246·1	12·91				
	1910·660	244·0	12·51	**12345**	1907·710	87·3	2·37
	1910·668	245·4	12·51				
Mean	1910·652	245·2	12·64	**12753**	1907·710	161·8	3·12
					1908·765	160·1	3·09
				Mean	1908.238	161·0	3·11

Dominion Observatory,
Ottawa, Canada,
October, 1910.

THE ELEMENTS OF 93 LEONIS

By J. B. Cannon

THE star 93 Leonis ($\alpha = 11^h\,43^m$; $\delta = +20^\circ\,46'$) was announced to be a binary by Campbell and Wright in 1900,* from the measures of four plates taken by them in that year. It belongs to group *F*8 of Miss Cannon's classification. It was under observation here at three different periods in the years 1908, 1909, and 1910. During that time seventy-two plates were taken, the instruments used being the old and new single prism spectrographs.

The lines are not at all well defined and in many cases large differences result between the velocities given by the various lines and the mean of the plate. The lines appearing are chiefly due to iron, hydrogen, magnesium, titanium and carbon. Several lines of each element were measured but in the determination of the elements the titanium lines were discarded as so great differences between the velocities from its various lines existed that no dependence could be placed on them. A list follows giving the wave-lengths of the lines used and the element to which each is due :—

Wave-Length	Element	Wave-Length	Element
4861·527	*H*	4260·640	*C*
4549·766	*Fe*	4250·616	*Fe*
4481·400	*Mg*	4227·010	*Fe*
4415·301	*Fe*	4216·351	*Fe*
4404·927	*Fe*	4101·890	*H*
4352·006	*Mg, Cr*	4071·901	*Fe*
4340·634	*H*	4063·756	*Fe*
4325·939	*Fe*	4045·975	*Fe*
4271·760	*Fe*	3933·825	*Ca*

The period of oscillation was determined by the aid of the results obtained by Campbell and Wright from their measures of

**Astrophysical Journal*, Vol. XII., p. 255, 1900.

1900 and found to be 71·70 days. This was taken as being close enough, their observations being some forty periods away from the date of the first plate obtained here.

At the maximum of the curve the determination was somewhat unsatisfactory, the weather unfortunately being very bad at each return of the star to that part of its curve, so that only a few observations were obtained. Some time later a few plates may be taken to verify the results accepted.

The seventy-two observations were grouped into the following normal places :—

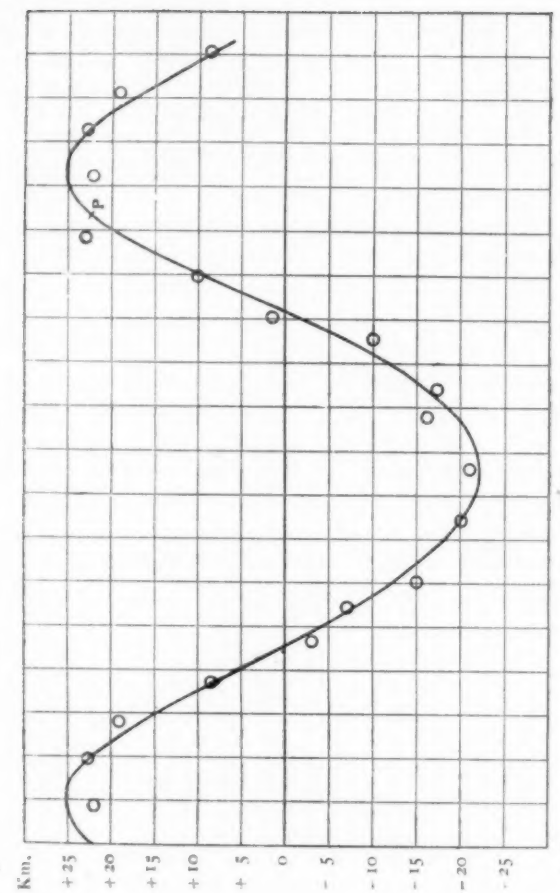
	Julian Date	Phase	Velocity	Residual O-C	Weight
1	2,418,317·48	37·28	− 20·2	+ 0·12	3
2	515·92	43·02	− 20·9	+ 1·25	2
3	497·50	48·93	− 16·1	+ 3·18	1·5
4	338·54	52·02	− 17·3	− 1·55	2
5	672·90	57·74	− 10·0	− 4·12	2
6	649·39	60·11	+ 1·5	+ 2·26	2
7	480·61	64·81	+ 10·1	+ 0·23	2·5
8	456·85	69·10	+ 22·9	+ 4·46	1
9	543·96	4·35	+ 22·0	− 3·13	2
10	556·70	9·61	+ 22·6	− 0·01	2
11	804·94	13·88	+ 19·1	+ 2·36	2
12	267·14	18·58	+ 8·6	+ 0·46	2
13	626·12	23·27	− 3·0	− 2·05	1
14	554·60	27·22	− 7·1	+ 0·94	2
15	601·07	30·09	− 15·0	− 2·55	2

Dr. King's graphic method was then used in determining the preliminary elements. These were :—

$$\gamma = -0{\cdot}578 \text{ km.}$$
$$K' = 24 \text{ km.}$$
$$e = {\cdot}1$$
$$\omega = 330°$$
$$T = 2{,}418{,}028{\cdot}85$$
$$P = 71{\cdot}7 \text{ days}$$
$$\text{and } \Sigma pvv = 147{\cdot}1$$

It was then decided to apply the method of Least Squares to reduce the value Σpvv if possible. Observation equations were formed by means of the formula of Lehmann-Filhés.*

* *A. N.*, No. 3242.



VELOCITY CURVE OF 93 LEONIS

From the observation equations there result the following normal equations :—

$$\begin{aligned}
29{\cdot}000x - 1{\cdot}182y - 2{\cdot}673z + {\cdot}426u - {\cdot}436v - 12{\cdot}375 &= 0\\
12{\cdot}975y - 2{\cdot}954z - {\cdot}632u + {\cdot}715v + 3{\cdot}205 &= 0\\
14{\cdot}556z - 2{\cdot}571u + 2{\cdot}620v + 5{\cdot}272 &= 0\\
15{\cdot}578u - 15{\cdot}517v + 4{\cdot}554 &= 0\\
15{\cdot}601v - 4{\cdot}601 &= 0
\end{aligned}$$

the solution of which gives

$$\begin{aligned}
x &= + {\cdot}3791\\
y &= - {\cdot}3354\\
z &= - {\cdot}4327\\
u &= + {\cdot}4741\\
v &= + {\cdot}8652.
\end{aligned}$$

Hence the corrections—

$$\begin{aligned}
\delta\gamma &= + {\cdot}379 \text{ km.}\\
\delta K &= - {\cdot}335 \text{ km.}\\
\delta e &= - {\cdot}018\\
\delta\omega &= + 1^\circ{\cdot}146\\
\delta T &= + {\cdot}405.
\end{aligned}$$

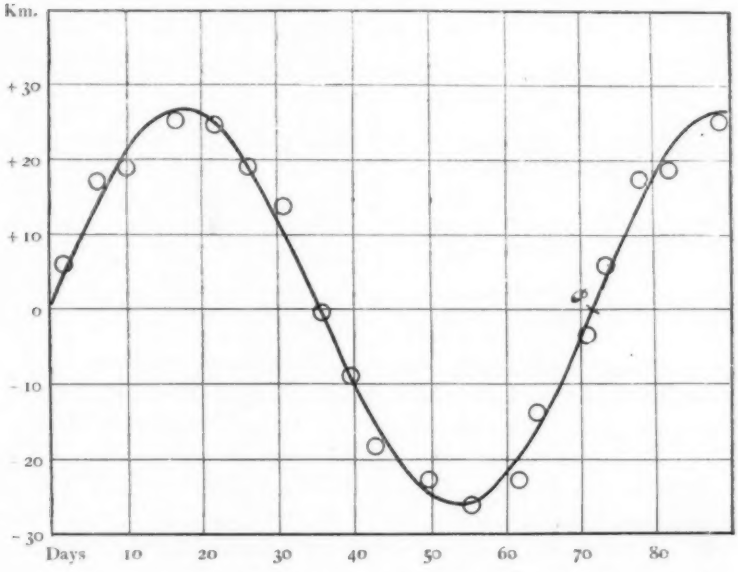
These results gave satisfactory differences between the residuals from the observation equations and the computed residuals, the highest difference being ·06. Σpvv was reduced to 137·4.

The probable error of a normal place was found to be ± 2·5 and that of an average plate—found by scaling residuals from the curve—to be ± 3·4.

Probable errors of the elements were also found and are given below, together with the final values accepted,—

$$\begin{aligned}
\gamma &= - {\cdot}20 \text{ km. } \pm {\cdot}31\\
K &= 23{\cdot}665 \text{ km. } \pm {\cdot}48\\
e &= {\cdot}082 \pm {\cdot}02\\
\omega &= 331^\circ{\cdot}\,15 \pm 10^\circ{\cdot}72\\
T &= 2{,}418{,}029{\cdot}255 \text{ J. D. } \pm 2^d{\cdot}1\\
P &= 71{\cdot}70 \text{ days}\\
a \sin i &= 23{,}250{,}000 \text{ km.}
\end{aligned}$$

Thinking the probable error of a plate rather high for this type of star, it was decided to try measuring the plates with the spectro-comparator. All the plates, with the exception of ten which were too faint for this method, were remeasured. The standard plates used were numbers 3172 and 3755, the former a sky plate taken with the new single-prism spectrograph, and the latter a sun plate taken with the old.



VELOCITY CURVE OF 93 LEONIS. — Comparator Measurements

The measures were grouped into fifteen normal places as before, each plate being placed in the same normal place as in the former work. These places are given below with the mean Julian day, the phase from final T, the mean velocity, weight, and residual from final curve.

NORMAL PLACES

	Julian Day	Phase	Velocity	Weight	Residuals O-C
1	2,418,317·48	49·83	− 22·7	5	+ 2·09
2	631·43	55·47	− 26·2	2	− 0·11
3	497·50	61·48	− 22·9	3	− 2·38
4	285·08	64·31	− 14·0	3	+ 1·75
5	672·90	70·97	− 3·5	4	− 2·32
6	649·52	1·76	+ 5·8	3	+ 1·11
7	480·61	6·32	+ 17·2	5	+ 2·57
8	456·85	10·22	+ 18·5	2	− 2·82
9	543·96	16·96	+ 25·0	3	− 1·66
10	558·42	21·89	+ 24·7	3	− 0·15
11	804·94	26·43	+ 18·9	3	− 0·30
12	190·95	30·85	+ 13·7	3	+ 2·77
13	590·48	36·03	− 0·4	2	+ 0·22
14	562·36	39·55	− 8·8	3	− 0·28
15	652·17	42·60	− 18·4	3	− 3·65

These normal places were plotted and the following preliminary elements were obtained graphically :—

$$\gamma = 0$$
$$K = 26 \text{ km.}$$
$$e = 0$$
$$P = 71{\cdot}70 \text{ days.}$$

The value of Σpvv was computed and found to be 207. One least squares solution was applied to the elements. Values of T and ω were assumed to be —

$$T = 2{,}418{,}088{\cdot}405 \text{ J. D.}$$
$$\text{and } \omega = 270°$$

for the purposes of the solution. This value of T was taken as fixed, for with e zero and ω 270° it would be impossible to obtain corrections to e, ω and T as two of the equations would be identical.

Observation equations were formed and normal equations found from them as follows :—

$$47{\cdot}x + {\cdot}183\,y + 1{\cdot}657\,z + 2{\cdot}498\,u - 9{\cdot}340 = 0$$
$$21{\cdot}018\,y - {\cdot}967\,z + {\cdot}800\,u - 11{\cdot}476 = 0$$
$$23{\cdot}699\,z + {\cdot}887\,u - 5{\cdot}108 = 0$$
$$25{\cdot}985\,u - 10{\cdot}570 = 0$$

The solution of these equations gave the following corrections to the elements :—

$$\delta\gamma = + \cdot 17 \text{ km.}$$
$$\delta K = + \cdot 54 \text{ ''}$$
$$\delta e = + \cdot 008$$
$$\delta\omega = + 0^\circ \cdot 81.$$

Hence the corrected values of the elements :—

$$\gamma = + \cdot 17 \text{ km.}$$
$$K = 26 \cdot 54 \text{ ''}$$
$$e = \cdot 008$$
$$\omega = 270^\circ \cdot 81$$
$$T = 2{,}418{,}088 \cdot 405 \text{ J. D.}$$
$$P = 71 \cdot 70 \text{ days.}$$
$$a \sin i = 26{,}170{,}000 \text{ km.}$$

These elements gave a new value of Σpvv of 196. This is a very small reduction — only about 5 per cent.— but the excellent agreement between the residuals — computed and observation equation — showed that further application of least squares would be useless.

The probable error of a normal place and of an average plate were computed and found to be $\pm$ 2·85 and $\pm$ 3·4 respectively. There were three plates, 1498, 1599 and 2134 which for some unknown reason gave abnormally large residuals. being $-$ 14·0, + 11·6, and + 13·0 respectively. If these be omitted the probable error of an average plate becomes $\pm$ 2·87.

The probable error of the elements were also computed and are attached to the final values in the table below. The table gives the elements obtained in the two ways of measuring, together with their probable errors.

Element	Micrometer		Comparator	
γ	− ·20 km.	± ·31	+ ·17 km.	± ·42
K	23·665 km.	± ·48	26·54 km.	± ·62
e	·082	± ·02	·008	± ·02
ω	331°·15	± 10°·72	270°·81	± 1°·26
T	2,418,029·255 J.D.	± 2d·1	2,418,088·405 J.D.	
P	71·70 days		71·70 days	
$a \sin i$	23,250,000 km.		26,170,000 km.	
Probable error of average plate		± 3·5		± 3·4 ± 2·9*
Probable error of average normal places		± 1·5		± 1·4

* Omitting plates, 1498, 1599, 2134.

Judging from the probable errors of an average plate, there is little difference between the two methods of measurement. There is something to be said in favor of each. Plates under exposed *may* be measured by the micrometer, which would not permit of measurement by the comparator. On the other hand it is impossible to obtain good agreement in the velocities obtained from the various lines in a spectrum like that of this star, and on such a spectrum, perhaps, the best work can be done with the comparator, which enables the measurer to strike a mean all along the plate.

As regards the elements obtained, K is the only one which shows a change worthy of note. The eccentricity is very small in both cases and the differences in ω need not be remarked upon.

In conclusion I wish to acknowledge my indebtedness to the Director for his interest and help in the work.

Dominion Observatory,
Ottawa, Canada,
November 1910.

THE SPECTROSCOPIC BINARY ϵ URSÆ MINORIS

By J. S. Plaskett

THE star ϵ Ursæ Minoris $\alpha = 16^h\ 56{\cdot}2^m\ \delta = +\ 82^\circ\ 12'$ was announced to be variable in its velocity by Professor Campbell in 1899.* It was placed on our observing list with the three-prism spectrograph in 1908 and a few plates were obtained. The star, however, is so faint—photographic magnitude 5·3—that even two and one half hours' exposure gave only a very weak spectrum, quite unsuitable for accurate measurement. When a short-focus camera was applied to the three-prism spectrograph in 1909, the star was again observed, and although greater intensity of spectrum was obtained the exposure time was inconveniently long. If the Lumiere "Sigma" plates were used, a fair spectrum could be obtained in an hour if the night was reasonably good, but these plates have the disadvantage of being very coarse grained, thus diminishing considerably the ease and accuracy of measurement. Consequently the spectra obtained were not felt to be of satisfactory quality, and after May 1910, the star was observed with the new single-prism spectrograph on Seed "27" plates. Even with this low dispersion over an hour's exposure was required, and many of the spectra obtained were of poor quality. It almost seemed therefore that this star was below the effective range of our equipment, and it was thought preferable to work up the plates already obtained, even if of inferior quality, than to attempt to obtain good high dispersion plates of so faint an object. Of the 55 plates obtained of this star 42 of the best were selected for use in determining the orbit, but the majority even of these 42 were not of good quality.

The star is of the spectral class $G5$ with good lines only slightly advanced in type beyond the sun, and consequently well adapted for the employment of the spectro-comparator, on which

* *Astrophysical Journal*, Vol. X., p. 179, October, 1899.

all the plates were measured. The values of the velocity, the phase and the residual from the final curve are given with other data in the following table:

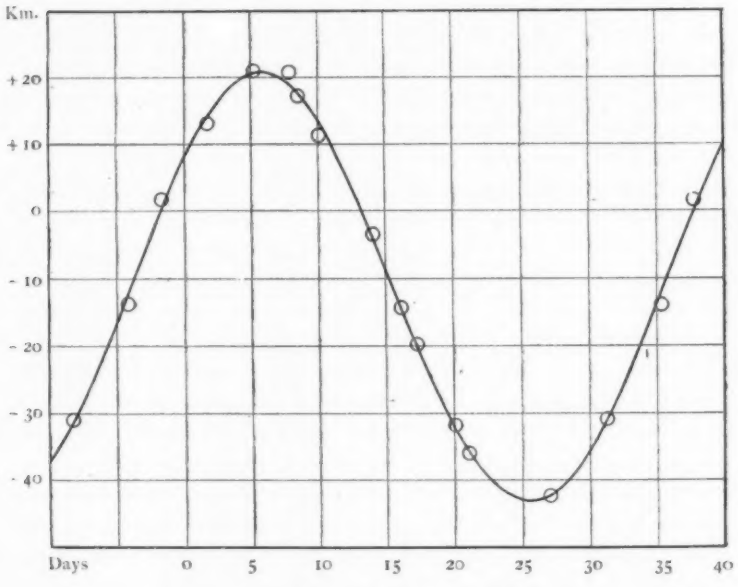
MEASURES OF ε URSÆ MINORIS

Plate Number	*Dispersion	Julian Date	Phase	Velocity	Residual O − C
1418	III L	2,418,021·72	21·72	− 41·2	− 3·7
1454	"	035·73	35·73	− 12·3	− 2·0
1516	"	006·85	27·368	− 43·9	− 2·15
1530	"	077·73	38·248	+ 3·6	+ 1·2
1555	"	087·77	8·806	+ 17·3	+ 0·2
1587	"	099·79	20·826	− 35·3	− 0·6
1868	"	192·62	34·902	− 15·3	− 1·5
2917	III S	609·58	17·35	− 17·9	+ 2·3
3023	"	652·44	20·728	− 32·6	+ 1·8
3042	"	659·46	27·748	− 43·2	− 2·0
3053	"	668·44	36·728	− 1·6	− 3·5
3067	"	671·47	0·276	+ 9·3	+ 0·6
3081	"	676·47	5·276	+ 20·9	+ 0·15
3084	"	679·45	8·256	+ 19·5	+ 1·1
3117	"	687·46	16·266	− 14·4	+ 0·6
3131	"	691·47	20·276	− 30·8	+ 1·9
3151	"	697·98	26·786	− 40·7	+ 1·7
3183	"	713·73	3·054	+ 17·7	0
3224	"	727·65	16·974	− 20·2	− 1·8
3292	III R	736·82	26·144	− 41·8	+ 1·0
3310	"	741·72	31·044	− 32·5	− 0·6
3326	"	742·91	32·234	− 25·1	+ 1·9
3337	"	748·70	38·024	+ 2·3	+ 1·0
3359	"	757·79	7·632	+ 21·5	+ 2·1
3372	"	764·78	14·622	− 5·4	+ 1·1
3426	I	797·69	8·05	+ 22·1	+ 3·4
3427	III R	797·75	8·11	+ 19·6	+ 1·0
3435	I	799·77	10·13	+ 11·9	− 1·4
3439	"	802·78	13·14	+ 1·1	+ 0·1
3448	"	804·69	15·05	− 10·7	− 2·1
3455	"	811·70	22·06	− 40·2	− 1·7
3461	"	819·85	30·21	− 36·0	− 1·0
3463	"	820·70	31·06	− 30·4	+ 1·4
3470	"	827·72	38·08	− 0·5	− 2·1
3476	"	832·75	3·628	+ 14·7	− 4·2
3492	"	846·70	17·578	− 21·3	0
3495	"	848·70	19·578	− 27·3	+ 2·6
3554	"	886·77	18·166	− 24·4	+ 0·6
3566	"	895·70	27·096	− 41·4	+ 0·7
3611	"	916·67	8·584	+ 15·3	− 2·2
3630	"	924·52	16·434	− 17·2	− 1·6
3732	"	957·56	9·992	+ 10·0	− 3·7

* III L 10·1, III S 18·6, III R 20·2, I 33·4 tenth-metres per mm. at $H\gamma$.

The period was soon seen to be in the neighborhood of 40 days and when all the observations were plotted and compared

with the early measures of Campbell in 1897 and 1899 the period was finally accurately determined as 39·482 days, which can hardly be in error more than one figure in the last place. The initial epoch was taken as Julian Day 2,418,000·00, and with this and the period of 39·482 days the phases given in the fourth column were computed.



VELOCITY-CURVE OF ε URSÆ MINORIS

As it was intended to correct the solution by the method of least squares the above 42 plates were collected into 14 normal places well distributed over the velocity curve and with no great difference of phase in any one group. Through these normal places velocity curves were drawn graphically by the method of Dr. King. The curve apparently best fitting the observations had the following values for elements.

Period, $U = 39{\cdot}482$ days
Eccentricity, $e = 0{\cdot}05$
Half amplitude, $K = 32{\cdot}0$ km.
Long. of apse, $\omega = 0^{\circ}$
Time of Periastron, $T = 5{\cdot}75$ days = Julian Day 8,005.75
Velocity of system, $\gamma = -12{\cdot}1$ km.
Greatest Positive Velocity, $N_1 = +21{\cdot}5$
" Negative " $N_2 = -42{\cdot}5$.

The phase from Periastron of the normal places given in the table below was obtained from the above value of the time of periastron passage, and the preliminary residuals were computed from the above elements by the help of Astrand's Tables.

NORMAL PLACES OF ε URSÆ MINORIS

No. of Group	Phase	Phase from Periastron	Velocity	Residual Preliminary	Residual Corrected	Wt.	Eph.-Eqn.
1	7·907	2·157	+ 20·86	- 1·70	- 1·79	1/2	+ ·03
2	8·586	2·836	+ 17·70	- 0·08	+ 0·01	2/3	- ·05
3	10·084	4·334	+ 11·27	+ 1·49	+ 2·24	1/3	- ·08
4	14·128	8·378	- 3·23	- 2·83	- 0·68	1/3	- ·05
5	16·056	10·306	- 14·80	- 1·03	+ 1·17	1/2	+ ·13
6	17·392	11·642	- 19·83	- 2·42	- 0·47	3/4	+ ·06
7	20·106	14·356	- 31·58	- 1·53	- 0·56	1/2	+ ·04
8	21·132	15·382	- 35·92	- 0·38	+ 0·22	2/3	+ ·07
9	27·021	21·271	- 42·39	+ 0·57	+ 0·13	1	0
10	31·267	25·517	- 31·06	- 0·74	- 0·04	3/4	+ ·07
11	35·361	29·611	- 13·80	+ 0·11	+ 1·74	1/2	+ ·01
12	37·791	32·041	+ 1·59	- 2·88	- 1·48	1	- ·05
13	1·761	35·493	+ 13·00	+ 1·03	+ 1·25	2/3	- ·05
14	5·276	39·008	+ 20·90	+ 0·49	- 0·11	1/8	- ·01

From these normal places and the preliminary elements given above, observation equations were computed by the method of Lehman-Filhés.* When the eccentricity is very small, experience has shown that it is quite useless to carry through corrections for both ω and T. Moreover the period was considered determined, and hence equations connecting the values of $\delta\gamma$, δK, δe and $\delta\omega$ with the residuals were computed.

* *A. N.* 3242.

OBSERVATION EQUATIONS, ϵ URSÆ MINORIS

1·00	+ ·979	+ ·719	− ·370	− 1·70	1/2	+ ·628
"	+ ·929	+ ·533	− ·477	− 0·08	2/3	+ 1·905
"	+ ·777	+ ·037	− ·686	+ 1·49	1/3	+ 2·618
"	+ ·189	− ·973	− ·990	− 2·83	1/3	− 3·604
"	− ·116	− ·941	− ·986	− 1·03	1/2	− 2·073
"	− ·317	− ·718	− ·930	− 2·42	3/4	− 3·385
"	− ·656	+ ·014	− ·708	− 1·53	1/2	− 1·860
"	− ·756	+ ·303	− ·591	− 0·38	2/3	− ·414
"	− ·926	+ ·906	+ ·219	+ 0·57	1	+ 1·769
"	− ·615	− ·098	+ ·746	− 0·74	3/4	+ ·293
"	− ·050	− ·980	+ ·995	+ 0·11	1/2	+ 1·075
"	+ ·338	− ·853	+ ·958	− 2·88	1	− 1·437
"	+ ·817	+ ·157	+ ·642	+ 1·03	2/3	+ 3·646
"	+ 1·046	+ ·986	+ ·083	+ 0·49	1/8	+ 3·605

The above observation equations gave the following normals:

$$\begin{aligned}
8{\cdot}292\,x - {\cdot}094\,y - {\cdot}673\,z - {\cdot}328\,u - 6{\cdot}759 &= 0\\
-{\cdot}094\,x + 3{\cdot}781\,y - {\cdot}149\,z + {\cdot}206\,u + {\cdot}118 &= 0\\
-{\cdot}673\,x - {\cdot}149\,y + 3{\cdot}829\,z - {\cdot}239\,u + 5{\cdot}133 &= 0\\
-{\cdot}328\,x + {\cdot}206\,y - {\cdot}239\,z + 4{\cdot}478\,u + 1{\cdot}293 &= 0
\end{aligned}$$

where $x = \delta\gamma$

$y = \delta K'$

$z = K'\delta e$

$u = K'\delta\omega.$

Their solution gives the following values to the corrections:

$$\begin{aligned}
\delta\gamma &= + {\cdot}7022\\
\delta K' &= - {\cdot}046\\
\delta e &= - {\cdot}0387\\
\delta\omega &= - {\cdot}0094 = - 0^\circ{\cdot}54.
\end{aligned}$$

Applying these corrections to the preliminary values above we obtain the following elements for ϵ Ursæ Minoris with their probable errors.

Period, $U = 39{\cdot}482$ days

Eccentricity, $e = 0{\cdot}0113 \pm {\cdot}0103$

Half Amplitude, $K' = 31{\cdot}954$ km. $\pm {\cdot}330$ km.

Longitude of Apse, $\omega = 359^\circ{\cdot}46 \pm 0^\circ{\cdot}55$

Velocity of System, $\gamma = - 11{\cdot}398 \pm {\cdot}224$ km.

Time of Periastron Passage, T = J. D. 2,418,005·75

Greatest Positive Velocity, $N_1 = + 20{\cdot}198$
" Negative " $N_2 = - 42{\cdot}990$.

Projection of Semi-axis, $a \sin i = 17{,}346{,}000$ km.

Σpv^2 has been reduced by the solution from 20·80 to 9·21 giving the probable error of a normal place of unit weight as ± 0·64 km.

The residuals in the table of measures were obtained by careful scaling from the final velocity curve and the probable errors of a plate were obtained from these residuals.

Probable Error,	Average	Plate		± 1·23
"	"	"	3-Prism Plate	± 1·11
"	"	"	1 " "	± 1·64.

Considering the quality of most of the plates and the fact that the best of the three-prism plates are made on the coarse grained Sigma Emulsion, and with a dispersion of 18·6 and 20·2 tenth metres per mm. at $H\gamma$, these values are as low as could reasonably be expected.

The velocity curve corresponding to the final elements is given in the figure, the normal places being represented by circles.

I have much pleasure in acknowledging the interest shown by the Director, Dr. W. F. King, in this work.

Dominion Observatory,
Ottawa, Canada,
Nov., 1910.

MEETINGS OF THE SOCIETY

AT TORONTO.

November 8.—The Secretary, Mr. J. R. Collins, reported to the meeting that communications had been received from Winnipeg regarding the institution of a centre of the Society there, and he presented a list of thirty-one residents of Winnipeg who were applicants for membership in the Society. The Secretary also stated that inquiries had been received from parties in Guelph, regarding the formation of a centre there.

Mr. Andrew Elvins briefly discussed the subject, "Astronomical Cycles and Terrestrial Climate," illustrating his remarks with simple models. Mr. Elvins contended that there must be a periodic climatic change due to the precession of the equinoxes. The following is a brief outline of his argument :—The plane of the ecliptic is a fixed plane in the heavens, and is crossed by the earth's equator at two points which we shall call the nodes. The angle measured at the earth's centre is 23½° (approximately); one solstice must thus be above and the other below the ecliptic. As the equator is inclined to the ecliptic and the earth rotates on its axis (which is at right angles to the equator), keeping the node always on the ecliptic, the hemispheres must be always changing their exposure to the sun, causing a surplus of *heat* in one hemisphere and a deficit of heat (or a surplus of *cold*) in the other at the same time. The interval from a maximum of heat in one hemisphere to the next maximum in the same hemisphere being a *precession period*, about 26,000 years.

Rev. D. B. Marsh, of Springville, dealt with the subject. "The Surface of the Sun." Several problems connected with investigations on the sun were mentioned; for example, the mass, motion, form and nature of the surface, radiation, chemical constitution, etc., and the form and nature of the surface were discussed more fully. Slides explaining the photosphere, sun spots, faculæ, reversing layer, chromosphere and corona were shown. Theories of the nature of the sun and sun spots were also discussed, and the convection theory as an explanation of the latter was put forward as the most probable.

Dr. Marsh announced the presentation by Mr. J. R. Stratton to the Peterborough Centre of the Society of a 3-inch telescope. He also showed some photographs of the total solar eclipse of 1905, made with a small camera.

November 22.—The following were elected members of the Society:—

Marcus Holmes, 538 Bathurst St., Toronto.

Arthur Kennedy, c/o Harry Webb Co., Buchanan St., Toronto.

Also, the following residents of Winnipeg, Man.:

C. E Bastin,	H. C. Howard,	Mrs. A. B. Palk,
Rev. Father Blain,	Mrs. G. O. Hughes,	Miss Porah,
Mrs. H. W. A. Chambré,	Mrs. L. B. Ireland.	F. Powell,
R. E. Collins,	Mrs. A. Langford,	H. E. R. Rogers,
Dr. Mary Crawford,	Chas. E. Lewis,	C. H. E. Rounthwaite,
Mr. Dempster,	Miss Macgregor,	Miss C. I. Seale,
N. G. Dinnen,	S. Mackay	Mr. Sisler,
Miss G. Fisher,	W. Malpass,	Jno. G. Stiven,
E. A. Garratt,	Mr. McCready,	Dr. H. R. Tweed.
H. Gatrell	Prof. N. B. McLean,	L. D. Walker,
	F. Whittaker.	

The Secretary reported to the meeting that at a meeting of Council held on Nov. 29, an application for the institution at Winnipeg of a Centre of the Society was presented, and Council decided in favor of the proposal, this action to become effective

when those making application had been elected members of the Society. The election of those just named thus completed the formation of the new Centre.

The paper for the evening was by Dr. Otto Klotz of the Dominion Observatory, Ottawa, the subject being "Our Earth in the Universe." The subject was discussed from many points of view, and was presented in a lucid and very pleasing manner. The entire paper appears in the present issue (page 427).

December 6.—Mr. John Patterson, B.A., of the Meteorological Observatory, gave an interesting lecture on "Earthquakes and the Instruments used in Measuring them." A brief outline of earthquakes recorded in early times was given and theories of their cause held by the Greeks, Japanese and others; as well as later theories, such as:—

(1) The downfall theory, *i. e.*, the falling of the earth's crust into subterranean caverns.

(2) Molten matter forcing its way into fissures.

(3) Action of steam in the central portions of the earth.

(4) Volcanic action.

The modern theory is that earthquakes are due to strains set up in the crust of the earth.

The various kinds of shocks as indicated by the transmission of the disturbance were discussed, and the character of the regions in which shocks are prevalent was described. Lantern slides were shown of several of the most destructive earthquakes of recent times. The nature of the shock was indicated by the ruins left behind.

The methods of measuring earthquakes were described, and the lecturer and his assistant went to considerable trouble and care to present a form of instrument in actual operation. These efforts were highly appreciated by the audience.

December 20—The lecture of the evening was given by Mr. G. Parry Jenkins, of Hamilton, on "A Plea for the Reflector." The speaker described the two classes of telescopes, refracting and reflecting, and outlined the advantages of the latter. The

construction and forms of mounting were also described. In addition Mr. Jenkins gave a very interesting historical account of the efforts of Sir William Herschel, Foucault, Webb, Calver, With and Ritchey in their endeavors to obtain large reflectors of good definition. The method used by Foucault for testing was also discussed.

The lecture was especially interesting through personal references to Webb, With, Calver and other British workers.

L. G.

At Ottawa

November 10, 3 p.m., at the Observatory.—Mr. W. E. Harper, M.A., gave a paper on the "Irregularities in the Velocity Curves of some Stars, with Suggested Explanations."

Mr. Harper first explained what is meant by radial velocity, and showed how the radial velocity of a star is measured by the shifting of the lines of its spectrum. A series of spectrograms or photographs of the star's spectrum, taken at proper intervals, enables the observer to plot the velocity curve and thus to obtain the period of a revolution of the star in its orbit. From the velocity curve all the elements of the orbit of the star can be deduced. The orbits are generally circles or ellipses, but in some cases velocity curves are irregular in outline, and motion in an elliptic orbit does not faithfully represent the observations.

The first irregularity of this kind was noted by Campbell, of the Lick Observatory, about ten years ago. He discovered that the orbital period corresponded with the light period. He suggested several plausible explanations. One was that a satellite whose period was $\frac{1}{3}$ of that of the primary was swaying the latter in and out of its mean orbit; another was that tidal action accounted for the light variation and might also cause velocity deviations. The second case, noted by Curtiss, was also explained by tidal action; and while his explanation was sufficient to explain this case, it fails to account for irregularities found later.

The third case was noted at the Dominion Observatory, in which case there was no light variation. Out of sixteen orbits of

stars determined here, seven have peculiar deviation effects.

Mr. Harper then spoke of some of these cases. θ Aquilæ has a period of 17 days and a disturbance which repeats itself twice in that time. This star has also been observed by Dr. R. H. Baker of Allegheny Observatory, who by means of fine-grained plates has been able to obtain spectra of the fainter star of the system, and says the oscillation can be explained as a blend effect. ϕ Persei, recently studied here by Mr. J. B. Cannon, has also a secondary oscillation of one-half period. In the case of ϵ Herculis there are traces of a second spectrum. Mr. Harper then went on to explain in detail the effect of this second spectrum. In the case of ϵ Herculis the irregularity in the velocity curve might be explained as due to it. Several other particular cases were enumerated by Mr. Harper, after which he discussed the question in general, showing that many causes may tend to produce the effects noted. Two of these causes, viz., tidal action and the resistance of the medium in which the star moves, were treated in detail.

November 24, 8 p.m., in Y. M. C. A. Hall.—The subject of the evening's lecture was "The Planet Venus," which was ably presented by Mr. Joseph Pope, C.M.G. Mr. Pope first spoke of astronomy as viewed from the amateur's standpoint, and showed how it compared favorably with any other science as a pastime; no laboratory or instruments being absolutely essential, and a simple everyday observation of the astronomical phenomena occurring about us being sufficient to reveal the main facts. He then showed how an amateur might for himself discover the motions of Venus, and if provided with a telescope, might see her phases. He then gave a summary of the most important truths known in regard to the planet, discussing among other matters her phantom satellite, her phases, the visibility of Venus as a crescent, the transit across the sun's disc, etc.

An appreciative audience heartily endorsed a vote of thanks to the lecturer at the close.

C. E.

AT HAMILTON

November 25.—The lecture of the evening was on "The Physical Constitution of the Stars," by Mr. W. Balfour Musson, of Toronto. In opening his address, the speaker said he thought it would be of interest to know that the establishment of a branch of the society in Regina was an accomplished fact, that one in Winnipeg was pratically decided upon and that enquiries had been received from Guelph.

Not much over fifty years ago it would have been considered improbable, if not impossible, that man should ever be able to tell anything definitely about the constitution of the stars, but the "new astronomy" really began to stir when Newton asked why light appeared colored when passed through a prism.

The lines in the spectrum were noticed so early as 1802 by Wollaston. Fraunhofer, in 1815, mapped the lines, and noticed the connection with sodium lines. Kirchhoff completed the work of connecting the spectra of the elements with the lines in the solar spectrum, making his great announcement concerning them in 1859. Progress was now rapid, the work being carried on by Huggins, Vogel, Secchi, Rutherfurd and others. In 1864 Huggins attacked the nebulæ, which at this time had come to be considered all resolvable. The difference was immediately observed, and the question settled that at least some nebulæ were glowing gas. Since then the classification of the stars according to their various spectra had been attempted; the differences being considered as indicating the age of the star. Secchi's classification into four groups was the basis of most classifications.

I. The white or bluish stars with a continuous spectrum crossed by hydrogen bands, the metallic bands being absent or subordinate. Examples, Sirius, Vega, etc.

II. Yellow stars, with spectra in which the hydrogen bands were less prominent and the metallic lines more in evidence. Examples, our sun, Capella,

III. Red or orange stars, showing bands or flutings. Examples, Antares and α Orionis.

IV. Red stars, showing bands similar to the last class, but with the sharp edge of the flutings toward the other end of the spectrum.

Some of the bands in Class III were found to be due to titanium oxide, while those in Class IV. were due largely to carbon.

At the close of the lecture a hearty vote of thanks was tendered the lecturer for his most interesting address.

December 9.—A. T. Colville, 24 Gore St., Hamilton, was elected a member of the Society.

Rev. D. B. Marsh, of Springville, gave an illustrated address on "The Surface of the Sun."

At the request of the local president, Mr. G. P. Jenkins, Dr. Marsh exhibited a sample of a sidereal watch which he had had placed upon the market.

The lecturer said that the sun could be studied as our dominating body or as a typical star. As the latter he wished to present it.

The problems of the sun are numerous — its dimensions, mass, motions, radiation, temperature, source of heat, constitution, etc. Several of these were discussed, leading to an examination of the sun's surface, with its faculæ, dusky envelope, reversing layer, chromosphere, corona, and so on.

The theory of the "rice grains" being puffs of highly heated gases protruding through the "dusky layer" was referred to, and the statement made that though they compose but $^1/_5$ of the sun's surface, yet ¾ of light and heat emanate from them. Sun spots were described, and the various theories concerning them examined, viz.: that they were caused by dark bodies between us and the sun; that they were clouds, or waste material, scoriæ, etc., or the uncovering of mountain tops, foreign matter falling upon the surface and taking time to melt, the escape of gas from centre discovering the dark interior, storms in the fluids composing the sun's atmosphere causing rifts, and lastly the

accumulation of cooled gases in a down rush to the surface.

At the close a hearty vote of thanks was tendered the lecturer.

T. H. W.

AT PETERBOROUGH

November 5. — This, the first meeting of the Peterborough Centre for the session, was held in the assembly hall of the Collegiate Institute, and was especially notable for two reasons. First, it was the occasion of the presentation to the Centre by Hon. J. R. Stratton, M.P., of an excellent 3-inch refracting telescope; second, the address of the evening was by Professor A. T. De Lury, of Toronto, the president of the entire Society.

Mr. H. B. Collier, the local president, occupied the chair. He asked the secretary, Rev. D. B. Marsh, to make a few remarks. The latter stated that the local Society had been the means of arousing the enthusiasm of a great many, and the interest was steadily on the increase. He spoke of the fact that once in the early summer a large party of young people came out from the city to his place in automobiles, in buggies and on bicycles, at half past three in the morning, for the purpose of seeing the comet, which, however, they did not see, as it was a cloudy night. But it was an evidence of the growing interest.

The Presentation.

Mr. Stratton, on being called to the platform, said he was glad to be present among such high-minded persons as students of astronomy. It always, he said, gave him great pleasure to do anything that would help an organization, which, like the Peterborough Centre of the Royal Astronomical Society, was so progressive and up-to-date. We are all, at times, "up in the air," but not in an astronomical sense. We did not get as far as the sun, the moon, or the stars. Like most people, he had at all hours of the day and night witnessed the reflection of the sun, moon and stars; but he must admit that he was unable to talk to the members of the Society as he would like. Astronomy was a most interesting and attractive study, but unfortunately he had

not as much knowledge as he should wish to possess of a study which, in a general way, was so beneficial and had so important a bearing upon human progess. To study the stars and great bodies of the heavens to advantage, needs an assistance to vision, and he had felt that his desire to promote culture among his fellow citizens could take no better form, especially as regards the Astronomical Society, than to place at its disposal what he was told was a good telescope, and which he had much pleasure in formally presenting to the Centre. He did so with the earnest wish that his aim and expectation in regard to its influence would be fully realised, and with the hope that as the members of the Society looked up through it, the stars would look down upon the Society, flourishing and growing, as well numerically as in the acquisition of helpful knowledge.

Mr. Stratton's remarks were greeted with applause, and Mr. Collier, on behalf of the Centre, spoke of its sincere appreciation of Mr. Stratton's munificence. Ths presentation, he said, was an evidence of the practical interest in the Society. It was all very well to hear lectures on astronomy, but the real interest came on looking through an instrument at the heavenly bodies. He thanked the kind donor most heartily.

Mr. T. A. S. Hay, in moving a vote of thanks to Mr. Stratton, said that the Society heretofore, had been living on the generosity of the Government, as far as the supplying of telescopes was concerned, but now, through the kind thoughtfulness of Mr. Stratton, a great anxiety has been relieved. He hoped his worthy example would be followed by others.

Mr. D. Walker, in seconding the motion, said that Mr. Stratton never did things by halves, and on this occasion had shown his interest in the Society in a very practical manner. It gave him much pleasure to second the vote of thanks.

Professor De Lury's Address.

Professor De Lury, the speaker of the evening, was next introduced. He was glad to avail himself of the invitation to be present. He was glad to be here to note the increasing interest

in the Society. The work was extending very rapidly. A few years ago there existed only the parent centre at Toronto, but now there are five centres, and another one soon to be organised at Winnipeg. Two of these centres, the one at Hamilton and the one here, were formed through the effective energy of Dr. Marsh. He spoke of the generosity of the governments, both at Ottawa and at Toronto, and the assistance they had in helping on the work. He was glad to know that the characteristic public spirit of Hon. Mr. Stratton had shown itself in such a splendid way. The instrument which he had presented was perfect in construction, and an excellent one in every detail. It would be a great stimulus to the work, and while this Centre had added its thanks to Mr. Stratton, he wanted to thank Mr. Stratton on behalf of the entire Society of Canada. He was pleased to know and appreciated the fact that, the Astronomical Society had Mr. Stratton's good will.

Coming to his subject, Professor De Lury stated that he was to speak on the problems of "Astronomy of To-day." When one recalled the problems that have presented themselves, he appreciated to a greater extent the significance of the questions of to-day. When men began enquiring into the cause of the remarkable succession of events, day after day, the solution they arrived at was the most natural, namely, that the earth was the centre of things, and the heavenly bodies revolved around it. As men travelled they were led to the conclusion that the heavenly bodies were not near the earth, but results of study have shown that while the moon is comparatively near the earth the sun is much farther away, and the stars are at infinitely vast distances from the earth. The next idea was that the earth itself rotated on its axis.

No sooner had one problem been solved than another one arose. The question was asked: "Why is it that these heavenly bodies move thus around the sun?" The idea was conceived that the matter in the sun exercised an attractive influence on the bodies and caused them to revolve in orbits of their own. This solution did not readily appeal to the learned world, and

for more than a century remained in doubt. "Do the stars attract one another?" These motions might be going on, but the distances are so great that the motions would be scarcely perceptible.

This brings the student to the second great stage of the development of astronomy. We see a great source of heat and light in the sun, and the question comes: "What sustains it, and will it last?" When one reflected, he would find there was very little work done that was not done by the sun. Electric light was made from the working of the sun. The motion of the falling water is stored and brought to us as light, but the water comes in streams from the hills and the mountains, where the action of the sun condensed the vapor and made water. The very energy of ourselves comes from the sun, and our food is the result of its work. The planets were once part of a great nebulous mass, which afterwards became condensed and left a residue, which was now called the solar system. The speaker then went on to explain the theory of light, and concluded his lecture by showing a number of slides illustrating the sun.

The hearty thanks of the audience for his excellent lecture was shown Professor De Lury by an outburst of applause.

November 15. — The local president, Mr. H. B. Collier, opened the meeting with a few remarks relative to the pleasure and benefit accruing to the Society from the use of the two telescopes now being loaned to the various members. These, in addition to three owned by private members, brought astronomy to a more practical basis, and afforded the user a means of obtaining a first-hand knowledge of the heavens.

Mention was also made of the new sidereal time-piece which has been manufactnred under the direction of Dr. Marsh. A number of the members are using this watch and have found it of very superior quality, and Dr. Marsh was complimented on behalf of the centre.

"The Surface of the Sun" was the topic of a lecture delivered by Rev. Dr. Marsh. The assembly hall of the Collegiate

Institute was well filled, a large proportion of the audience being visitors. The lecture was illustrated throughout by a number of excellent drawings and photographs, which assisted materially in simplifying the arguments presented. The speaker described the sun and its various parts and gave some nine different theories as to the cause of sun-spots, and their characteristics. The latest and most probable of these theories was the torsion or vortex theory, ascribing the phenomena to the accumulation of cooled gases returning to the centre of the sun. An interesting discussion followed.

November 25.—Prof. C. A. Chant of the University of Toronto, addressed the Peterborough Centre in the Collegiate Institute. The lecture took largely the form of a "travel talk" the speaker describing a recent trip made to California by the Canadian route, the object of the trip being the great convention of the Solar Union, at Mount Wilson.

A large number of photographs of the scenes along the route and of the noted men participating in the concerted work of research, made the talk very interesting.

The Solar Union, as it is called, is an international society, or rather union of societies, for the purpose of concerted work and research on the sun. All the great nations are represented, some 22 societies being now on the roll. Canada is represented by the Royal Astronomical Society, and at the convention this year, Professor Chant of Toronto and Mr. J. S. Plaskett of Ottawa were the delegates.

Considerable progress has been made in the last few years in solar work, chiefly through the beneficence of Andrew Carnegie. This multi-millionaire set aside some twelve million dollars to endow the Carnegie Institution of Washington. The interest on this means $600,000 per year available for scientific purposes. By means of this great fund a unique observatory has been constructed on Mount Wilson in California for the sole pupose of the sun. From its great height of 5880 feet, and on account of its favorable climatic conditions, many discoveries have already

been made. This observatory uses chiefly the reflecting telescope, with mirrors of a foot in thickness to send the sun's rays in any direction desired. One of these unique telescopes is 150 feet in height, the tower being of double construction so that wind and heat will not warp or twist the inner tower, on which are placed the delicate instruments.

The lecture was most interesting throughout. The attendance was good. In the language of the newspaper reporter, "Judging by the increased attendance at the meetings of the Royal Astronomical Society this season, it is quite evident that a lively interest is being taken in this study by the citizens generally."

H. B. C.

At Winnipeg, Manitoba

Organisation of the Winnipeg Centre

On September 22, 1909, the Astronomical Association of Western Canada was organised. It was formed for the purpose of enabling all interested in astronomy to attain an elementary knowledge of the subject, and in order to give those with a preliminary acquaintance an opportunity of pursuing more advanced work.

The first meeting was called at the suggestion of Mr. J. P. Hughes. Mr. George Hall acted as chairman, Mr. Malpass was elected Recorder, and Mrs. L. B. Ireland, Secretary of the Association. The election of a President was left over for some time, until it was felt that the most suitable person had been found for the position.

In November of the same year, N. B. MacLean, M.A., Professor of Mathematics and Astronomy in the University of Manitoba, was asked to accept the Presidency of the Association.

Thereafter all meetings were held in the University Building, Broadway Avenue, and every encouragement was given to the new Association. The members of the University Faculty were kind enough to grant the use of a Lecture Theatre for all the meetings, the Professor of Physics very generously allowed

the fine projecting lantern to be used, while the Professor of Mathematics and Astronomy assisted greatly in the interest taken in the papers read by illustrating the subjects under discussion by means of lantern slides. In addition, the members were encouraged to make use of reference books and magazines in the library, and on certain evenings an opportunity was given of using the 5-inch Equatorial Telescope belonging to the Department of Astronomy.

It has been the aim to consider in the earlier part of the year the more simple problems, and towards the end of the session to take up more technical topics.

At each meeting every encouragement is given to questions, suggestions, and free discussion, the idea being to guard against too much reserve and formalism.

In November, 1910, the Association felt very strongly that it would be a source of great help to be incorporated into the Royal Astronomical Society of Canada, and the Secretary was asked to lay the matter before the proper body. The Winnipeg Centre received every assistance and encouragement in the reorganisation and wish to convey an appreciation to the officers of the Royal Astronomical Society of Canada for their good wishes. The following are the officers for the Winnipeg Centre:

President—Professor Neil B. MacLean.
Vice-President—Mr. C. E. Bastin.
Secretary—Mr. C. V. Stout, B.C.E.
Treasurer—Mr. Frank Powell.
Council—Mrs. L. B. Ireland, Mr. Howard, Mr. Collins. Father J. Blain, S. J., Mrs. Kemp.

WINNIPEG,
January 18, 1911

C. V. STOUT,
Secretary.

NOTES FROM THE DOMINION OBSERVATORY

TERRESTRIAL MAGNETISM

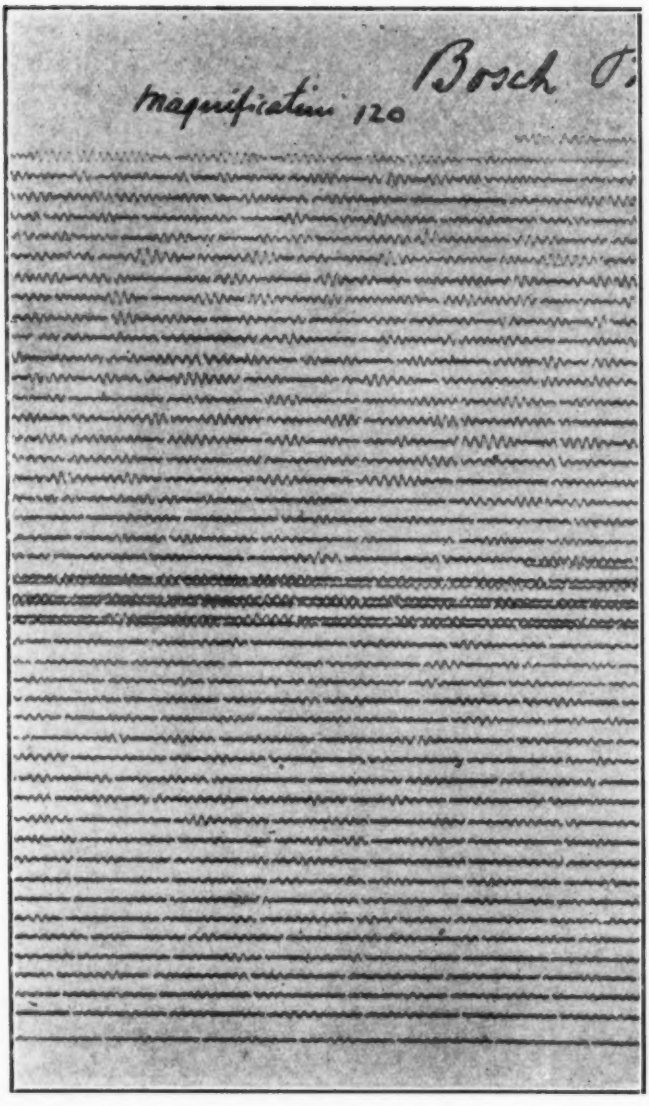
In continuation of the magnetic survey of the Dominion, the following stations, all along the Canadian Pacific Railway, have been occupied by Mr. C. A. French during the past season. The values for inclination and intensity will be published later.

Magnetic Results, 1910

Station	ϕ	λ	Date	Declination	Diurnal Range
	° ′	° ′		° ′	′
Chapleau	47 50·3	83 25·6	May 7, 9	4 16·4 W	14·8
Wayland	48 2·4	83 49·9	" 10, 11	5 8·8 W	12·2
Missanabie	48 18·8	84 5·2	" 14, 16	5 48·8 W	13·6
Grassett	48 27·3	84 37·6	" 20	3 46·1 W	12·6
White River	48 35·2	85 16·3	" 23, 25	3 11·9 W	15·5
Montizambert	48 41·3	85 38·6	" 27, 28	2 22·3 W	12·6
Heron Bay	48 39·3	86 17·3	" 30, 31	2 33·4 W	13·6
Middleton	48 47·7	86 40·3	June 4	17 48·9 E	19·6
Schreiber	48 48·5	87 16·6	" 7	0 31·7 W	12·9
Gravel	48 54·7	87 43·6	" 10	0 25·1 E	11·5
Nipigon	49 0·7	88 15·9	" 11, 13	1 7·0 E	14·2
Dorion	48 46·8	88 32·0	" 14	1 39·3 E	11·3
Mackenzie	48 33·0	88 58·5	" 15	2 49·3 E	11·3
Fort William	48 23·9	89 14·9	" 17	3 16·5 E	12·2
Kaministikwia	48 31·5	89 35·1	" 22	0 25·3 E	15·8
Raith	48 49·8	89 53·6	" 24	3 49·8 E	12·5
Savanne	48 57·0	90 14·0	" 27, 28	4 28·1 E	15·2
Niblock	49 6·3	90 41·3	" 30	4 54·5 E	15·0
Martin	49 15·3	91 7·9	July 2, 4	4 58·1 E	14·0
Ignace	49 25·4	91 40·5	" 6, 7	6 10·5 E	14·6
Taché	49 35·0	92 10·7	" 11, 12	6 57·4 E	14·1
Wabigoon	49 43·6	92 36·8	" 13, 14	7 39·0 E	15·5
Dryden	49 47·4	92 50·1	" 16, 17	8 14·1 E	20·6
Eagle	49 47·7	93 11·1	" 19, 20	6 34·7 E	17·2
Vermillion Bay	49 51·3	93 23·5	" 21	7 42·8 E	17·1
Hawke Lake	49 48·3	93 59·7	" 23, 24	7 28·4 E	17·7
Kenora	49 46·2	94 29 0	" 26, 27	10 0·4 E	14·8
Kalmar	49 45·7	94 58·0	" 28, 29	9 31·7 E	12·5
Rennie	49 51·5	95 33·3	" 30, 31	10 19·7 E	12·6
Whitemouth	49 57·0	95 57·8	Aug. 1, 2	10 57·0 E	18·2
Norquay	49 59·6	96 33·9	" 4, 5	11 23·0 E	18·2
Winnipeg	49 51·9	97 7·9	" 8, 9	13 56·7 E	13·8
Marquette	50 4·1	97 43·0	" 11, 12	13 17·7 E	15·2
Portage la Prairie	49 58·5	98 17·9	" 15, 16	9 26·9 E	15·9
MacGregor	49 58·4	98 47·4	" 17, 18	13 9·6 E	17·4
Carberry	49 52·5	99 21·6	" 19, 20	15 44·0 E	15·6
Brandon	49 52·0	99 58·8	" 24, 25	15 3·9 E	16·8
Griswold	49 46·9	100 28·7	" 26	16 4·6 E	13·5
Virden	49 51·3	100 55·7	" 27, 28	16 43·1 E	13·0
Kirkella	50 1·9	101 22·4	" 30, 31	16 13·9 E	11·2
Wapella	50 15·8	101 58·4	Sept. 1, 2	17 50·6 E	15·2
Broadview	50 22·3	102 34·7	" 3, 5	17 13·3 E	13·8
Wolseley	50 26·3	103 15·5	" 9, 10	18 18·1 E	17·8
Indian Head	50 32·2	103 39·5	" 12, 13	19 32·7 E	13·4
Balgonie	50 29·6	104 16·1	" 14, 15	18 57·6 E	12·7
Regina	50 26·9	104 36·8	" 16, 17	19 26·8 E	12·4
Pense	50 24·7	104 59·1	" 19	19 45·5 E	14·0
Moose Jaw	50 23·9	105 30·9	" 23	19 52·9 E	11·3

Otto Klotz.

Dominion Observatory
Ottawa, Canada



A sample of strong microseisms registered on the Bosch Photographic Seismograph, Ottawa, November 24, 1909. (1 min. = 15 mm.)

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

October, 1910

Temperature.—The mean temperature was above average throughout the Western Provinces and over the greater part of Ontario; stations in the more southern portion recording the largest positive departures. Winnipeg mean was $+4{\cdot}5^{\circ}$ from average; Medicine Hat $+4^{\circ}$; Toronto $+3^{\circ}$; Chatham $+3^{\circ}$. Small negative departures were registered in the Ottawa Valley and Eastern Townships, and also in the Maritime Provinces, while over most of Quebec the temperature was to a small extent above average. British Columbia, exclusive of the Kootenays, was slightly below average, the largest departure being near the coast.

Precipitation.—Precipitation was in excess of the average, except in a very few localities, from Algoma eastward to the Maritime Provinces and also throughout British Columbia, while from Lake Superior westward to the Mountains there was a very general deficiency. Light snowfalls occurred on several dates in the Western Provinces, and about the 27th to 30th in parts of Ontario.

November, 1910

Temperature.—From British Columbia to and including Ontario the weather during November was for the most part cold, and the mean temperature was generally below the normal,

while in Quebec and the Maritime Provinces the converse was the rule.

Negative departures from normal were from 1° to 4° in British Columbia, 1° to 5° in the Western Provinces and in Ontario, while in Quebec and the Maritime Provinces the positive departures ranged between 1° and 5°. In Southern Interior Districts of British Columbia and also in Southern Alberta differences were positive by 1° to 3°, this being also the case in the Districts of Algoma and Nipissing in Ontario.

Precipitation.—The amount of precipitation recorded during November was more than average over the larger part of Canada, but in Northern, and locally in the Peninsula of Ontario, the Kootenay Valley and Cariboo Districts of British Columbia, Alberta, Southwestern Saskatchewan, Eastern Quebec and the Southwestern Districts of the Maritime Provinces, the normal quantity was not reached. Snow fell in all parts of the Dominion and remained on the ground in many localities, the depth varying considerably with the district. In Manitoba and Saskatchewan it ranged between four and ten inches and in Ontario from one inch in southern districts to about twelve inches in Muskoka and Parry Sound.

Temperatures for October and November

Station	October		November	
	Highest	Lowest	Highest	Lowest
Yukon				
Dawson	48	−2	23	−24
British Columbia				
Atlin	48	16	36	−4
Agassiz	69	30	62	22
Barkerville	54	18	38	4
Kamloops	72	24	56	16
New Westminster	66	32	52	31
Prince Rupert	60	32	48	16
Vancouver	66	32	53	31
Victoria	64	36	55	33
Western Provinces				
Battleford	72	18	44	−6
Broadview				
Calgary	76	12	55	10
Carman	82	10		
Edmonton	78	19	44	−8
Medicine Hat	81	22	58	−4
Minnedosa	81	9	42	−8
Moose Jaw	87	13	41	−4
Oakbank	76	17	37	−20
Portage la Prairie	84	16	41	−9
Prince Albert	76	14	54	−4
Qu'Appelle	86	14	46	−8
Regina	87	11	50	−11
Swift Current	84	14	48	−2
Winnipeg	78	18	38	−8
Ontario				
Agincourt	72	24	58	25
Aurora	76	23	56	21
Bancroft	75	16	54	6
Barrie			54	19
Beatrice	74	19	55	14
Birnam	76	15	59	20
Bloomfield	71	23	57	16
Brantford	77	24	60	22
Bruce Mines	75	21	46	18
Chatham	82	23	62	19
Clinton	75	12	57	18
Cottam	73	10	69	18
East Toronto	72	23	55	24
Gravenhurst	74	20	53	16
Guelph	78	22	57	21
Haliburton	75	16	56	6
Hamilton	73	36	60	24
Huntsville				
Kenora	70	20	30	0
Kinmount	74	14	43	8
Kingston	70	27	56	17
Lakefield	71	24	58	18
London	79	14	60	19
Lucknow	77	17	44	17
Madoc	70	20	58	9
Meaford				
Midland	85	28	50	20
North Gower	79	25	60	15
Otoanbee	70	25	52	22
Ottawa	72	27	57	18
Owen Sound	77	22	48	18
Paris	79	24	60	23
Parry Sound	74	21	53	15
Peterboro'	75	18	56	19
Point Clark	71	25	53	22
Port Arthur	71	24	43	8
Port Burwell	78	23	49	22
Port Dover	73	23	52	21
Port Hope				
Port Stanley	72	23	57	18
Ronville	72	21	53	15
Sarnia	80	28	70	20
Southampton	75	29	60	22
Stonecliffe	74	16	51	8
Stony Creek	77	26	61	21
Stratford	75	21		
Toronto	73	25	57	26
Uxbridge	73	17	55	21
Wallaceburg	80	26	60	20
Welland	75	26	58	23
White River	70	18	36	8
Quebec				
Brome	77	24	55	5
Father Point	66	22	49	15
Montreal	73	28	53	20
Quebec	73	28	56	17
Sherbrooke	80	25	55	12
Maritime Provinces				
Charlottetown	65	28	56	22
Chatham	75	24	54	10
Dalhousie	65	30	65	20
Fredericton	77	24	54	16
Halifax	72	28	57	22
Moncton	74	23	57	17
St. John	62	30	54	26
St. Stephen	75	20	53	15
Summerside				
Sussex	69	21	56	20
Sydney	75	29	60	28
Yarmouth	65	28	61	27

MAGNETIC OBSERVATIONS

During the month of October the magnetic curves exhibited considerable restlessness in the magnetic forces, occurring chiefly from the 3rd to 6th, 11th to 13th and 19th to 27th. Auroræ were recorded throughout the Dominion during each of these periods, but generally of the third or fourth class.

In November the forces were particularly steady, with slight disturbances from 16th to 19th. Only in a few places in Northern Alberta were auroræ recorded.

Month	Mean of Month	Max.	Date	Min.	Date	Monthly Range	Amplitudes--Mean Daily	
							From hourly readings	From Means of Extremes
Declination								
	° ′	° ′		° ′		° ′	° ′	° ′
Oct.	6 5·4	6 37·6	27	5 24·4	27	1 13·2	0 9·2	0 24·1
Nov.	6 6·1	6 25·1	18	5 36·6	16	0 48·5	0 7·3	0 15·6
Bifilar								
	C.G.S.units							
Oct.	·16244	·16310	6	·16118	19	·00126	·00035	·00080
Nov.	·16249	·16204	1	·16167	19	·00082	·00023	·00050

Inclination	
Month	Mean
	° ′
October	74 39·4
November	74 38·8

Earthquake Records by Milne's Seismograph

TORONTO

R. F. Stupart, Director.

P.T. = Preliminary Tremors. L.W. = Large Waves. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1910	P.T Comm h	P.T Comm m	L.W. Comm. h	L.W. Comm. m	Max. h	Max. m	End. h	End. m	Max. Amp. mm.	Durat. h	Durat. m	Remarks
953	Oct. 4	23	11·0					23	11·3	0·02	0	0·3	Barely noticeable
954	" 4	No. PTs		23	19·3	23	20·3	23	48·0	1·05	0	28·7	Began suddenly
955	" 7	8	0·1					8	26·9	0·05	0	26·8	Thickg. Doubtful as to being seis.
956	" 7	13	15·6					13	22·6	0·1	0	7·2	Mark. thickening
957	" 16	2	32·8					2	36·7	0·05	0	3·9	Slight thickening
958	" 18	3	44·5					3	49·0	0·05	0	4·5	Slight thickening
959	" 18	3	57·0					4	2·0	0·05	0	5·0	Slight thickening
960	" 30	8	43·0					9	6·5	0·10	0	23·5	Thickening
961	Nov. 4	6	25·0					6	31·0	0·10	0	6·0	
962	" 6	20	40·5	V_2 20	46·3	20	53·4	22	10·0	4·1	1	29·5	Medium
		20	43·6	V_2 20	49·2								
				B 20	51·3								
963	" 7	13	07? about	Mixed up		with air		currents		preceding a			nd following
964	" 9	6	22·7	V_2 6	34·1	7	30·8	9	30·5	1·4	3	7·8	Conspicuous for duration of L.W.
				B 6	59·5								Vib. inc. at 824·3
965	" 10	13	22·6?					14	12·5	0·15	0	49·9	Mixed up with air current
966	" 12	18	33·3					18	47·3	0·05	0	14·0	
967	" 13	23	52·5							0·05	0	0·5?	Min. thickening
968	" 14	8	32·4	8	39·0			9	11·7	0·4	0	39·3	
969	" 15	14	40·9					15	43·5	0·1	1	2·6	Thick'ings mixed up with air cur.
970	" 26	4	31·7?							0·05		?	
971	" 26	5	1·6	V_2 5	11·5	5	56·2	8	10·6	1·2	3	9·0	Doubtful as to being seismic
				B 5	36·7								
972	" 29	3	31·8					3	49·5	0·2	0	17·7	much prolonged

Vibration of boom 14·8 seconds. 1 mm. = 0″·64

VICTORIA, B. C.

E. B. Reed. Superintendent.

No.	Date 1909	P.T. Comm. h	P.T. Comm. m	L.W. Comm. h	L.W. Comm. m	Max. h	Max. m	End h	End m	Max. Amp. mm.	Durat. h	Durat. m	Remarks
985	Oct. 4	23	12·7					23	15·7	0·1	0	3·0	Thickening
986	" 4	No. PTs		23	23·2	23	25·0	24	4·7	0·5	0	41·5	Max. close to the beginning
987	" 18	2	58·7					3	3·2	0·1	0	4·5	
988	Nov. 6	20	31·8	V_2 20	33·9	20	34·1	21	5·9	17·0	1	19·1	Vy. large
				20	36·9								
989	" 7	13	27·9	Mixed up		with air		currents					
990	" 7	13	31·5?	Mixed up		with air		currents					
991	" 9	6	14·6	V_2 6	26·5	7	3·1	9	8·1	1·05	2	53·5	Extended
				B 6	40·6								
992	" 10	13	2·6					13	33·1	0·05	0	30·5	Thickenings
993	" 12	18	42·5					18	46·3	0·05	0	3·8	
994	" 14	8	25·5					9	1·5	0·2	0	36·0	
995	" 15	14	42·5					16	3·7	0·6	1	21·2	[trace Gradual swelling of
996	" 26	4	54·1			5	30·5	7	28·5	0·8	2	34·4	Small and extended.
997	" 29	2	49·2					2	50·2	0·05	0	1·0	Brief thickening
998	" 29	3	19·0					3	49·2	0·05	0	30·2	

Victoria reports a local earthquake on the 30th November at 11h 59m 30s (Victoria time). Boom does not appear to be affected.

Vibration 15 seconds. 1 mm. = 0″·76.

J. Y.

BOOK REVIEWS

L'Origine Dualiste des Mondes. Essai de Cosmogonie Tourbillonaire. PAR E. BELOT. Paris: Gauthier-Villars, 1911.

In this very interesting speculation as to the evolution of worlds and systems, the theory of vortices of Descartes, so completely set aside through the theory of Newton, is called into play and assigned a new rôle supplementary to, and certainly not less important than that of gravitation. A tube-vortex, (tube-tourbillon) of gaseous or ultra-gaseous matter, endowed with a high velocity of translation, is supposed to encounter an irregular or amorphous nebula. The collision — analogous to that which is supposed to be the source of a Nova — causes a vibration in the tube-vortex, resulting in the formation of expansions and contractions which prepare the way for the separation of masses which are the elements of a system. Resting on this idea, the author offers an explanation, in particular, of the various facts commonly regarded as impairing or nullifying the theory of Laplace.

In a short time it is hoped that an extended review of this work will be given to the readers of the JOURNAL.

The Elements of Astronomy, principally on the mechanical side, intended for engineering students. BY N. F. DUPUIS, M.A., LL.D., F.R.S.C. R. Uglow & Company, Kingston, Ont., 1910.

While every year yields at least one new book on elementary astronomy, there seems always room for fresh treatment. The little volume written by Professor Dupuis will win for itself a distinct place. The order of treatment is natural and effective, the numerical examples and illustrations are ever to the point, and a nice mean struck between the merely popular and the severe and exclusively scientific. The paragraphs dealing with time, calendars, and eclipses, are particularly interesting and clear.

δ.

ASTRONOMICAL NOTES

At the International Solar Union, Mr. C. G. Abbot, director of the Smithsonian Astrophysical Observatory, gave a brief historical outline of the study of solar radiation. The most probable value of the solar constant of radiation appears now to be about 1·92 calories per square centimeter per minute. From the last few years work at the Smithsonian Observatory at Washington and Mount Wilson, there are fairly strong indications of frequent variability of the order of five or ten per cent. in the intensity of the solar radiation outside the earth's atmosphere, and there are also indications from the study of a longer interval that there is a periodic variation coinciding in time with that of sun-spot frequency, the maximum radiation accompanying the sun-spot minimum.

Professor Schuster said that it was desirable to study the variation of intensity of the solar radiation from different parts of the disk. The photosphere and absorbing layer are not separate and the effect from the two is not the same near the limb as near the centre of the disk. One problem can be treated mathematically and that is where the heat is given out by radiation only—neglecting convection. On this supposition, calculating the absorption of air which we should expect if there were no other agency than pure air, the result for the solar radiation agrees with that obtained by Abbot.

Regarding the Spectra of Sun-Spots, Professor Hale said :—In the spectra of sun-spots certain lines are double and others are triple. The same lines are always affected in the same

way in different spots. The iron line at λ 6303 is triple, sometimes wide, sometimes less separted. To show this requires high resolving power and extremely high dispersion. Experiments in the laboratory show that doubling, tripling, and even higher multiplication of metallic lines is produced by passing the light through a powerful electro-magnetic field. In a spot spectrum the components of some lines may be parallel and those of others may be convergent at the same time, showing differences of the electric field at different levels. It is possible from these differences to determine the direction of the axis of a vortex about a sun-spot.—*Publications, Astronomical Society of the Pacific*, No. 133.

The Distances of Red Stars.—Dr. H. Norris Russell classifies the parallaxes of stars measured at Cambridge according to spectral types, and finds that the percentage of orange and red stars increases with the distance from our system. A comparison of parallaxes of stars with large proper motions with parallaxes computed from Kapteyn's formula shows that the observed parallax of the red stars is nearly twice the computed value, and hence that redness is accompanied by intrinsic faintness, the reddest stars averaging one-fiftieth of the brightness of the sun. On the other hand the bright red stars Arcturus and Antares are known to be at great distances, and are probably at least 100 times as bright as the sun. This is in agreement with the hypothesis that there are two classes of red stars, one getting hotter and the other cooling.—*Proceedings American Philosophical Society*, No. 195.

Regarding the Discovery of Comets, W. F. Denning, in *Journal of British Astronomical Association*, No. 2, remarks:—"This is a field of labor specially suited to amateurs; it is one which promises ample reward, and they cannot be too strongly encouraged to take it up. Comet-seeking is easy work, not involving the employment of expensive instruments, and is sure to be successful if performed by a capable observer. Moreover, it is highly interesting, for, in the process of sweeping, attractive

objects are picked up, many beautiful fields of stars, star clusters, and nebulæ are encountered, and there is an excitement as well as a feeling of expectation about the work which afford a welcome stimulus to the observer and prompt him to pursue it in spite of, possibly, long-delayed success.

Many young amateurs are naturally ambitious, and would like to perform some meritorious feat bringing their names prominently before the scientific public. They should take up comet-seeking, for it will prove very instructive, entertaining, and probably successful.

ARISTARCHUS—The inner slope of the E. wall is crossed by three broad dusky bands, apparently radiating from the centre and broadening as they mount the slope; these objects do not show in old drawings of this formation, and, so far as I know, the appearance is quite unique on the moon's surface. I have traced some of them over the crest in the direction of Herodotus. It would be interesting if some observers would watch these dark markings, noting the time when they first appeared, and also when they disappeared, and if they varied at all in size or shape in the interval.

On the floor of Aristarchus, Schmidt shows a distinct craterlet close to the slope of the N.W. wall. This requires confirmation.—W. GOODACRE, *Journal of British Astronomical Association*, No. 2.

THE TIDAL OBSERVATIONS OF THE BRITISH ANTARCTIC EXPEDITION, 1907.—In the curve for Madras there are considerable irregularities, but it seemed impossible even to imagine any periodicity. At Karachi there does seem to be an inequality with a period of two to three days and a range of two or three inches. A succession of waves with three to five crests one after the other is observable at several parts of the curve. It seems quite likely that sea-seiches may exist in the Indian Ocean, and Karachi would be well placed for observing them.

These Indian results were not corrected for barometric pressure, and it may be worth while hereafter to submit them to a

more systematic examination. For the present, however, I am satisfied with the conclusion that periodicity is not to be seen in all cases, and that the oscillations of mean sea-level in the Antarctic Sea are many times as great as those in the Indian Ocean and Bay of Bengal. Thus it seems unlikely that imagination is responsible for the existence of the Antarctic sea-seiches, and we may hope that the investigations of Captain Scott's second expedition will throw some further light on the subject, and possibly also on the existence of a deep bay behind the barrier.— Sir George Darwin, *Proceedings Royal Society*. Series A. No. 572.

A Projection on Saturn's Outer Ring.—During the total eclipse of the moon on November 16, M. Jonckheere directed the 35-cm. equatorial of the Hem Observatory to Saturn, and found a bright projection extending outwards from the eastern extremity of the exterior ring. The projection was best seen with low powers (100 and 200), and its intensity decreased gradually, going from the outer edge of ring A on to the background of the sky. On November 20 and 24 the same projection was seen with difficulty (*Astronomische Nachrichten*, No. 4461).

Meteorology in Japan.—In the *Bulletin* of the Central Meteorological Observatory of Japan (No. 5, 1910) Mr. T. Okada discusses in great detail the rainy season in Japan, which usually extends from about the middle of June to the middle of July, and is the most important period for the cultivation of rice. To make the investigation more complete, five-day means are given for the whole year for a large number of stations in Japan and adjacent districts, with charts and a short discussion of each of the principal elements. The figures show that in Japan proper the rainfall reaches a maximum at the end of June or in the first decade of July; it then falls to a minimum in August, and again increases to a maximum in September or October. The rainfall of the season in question is chiefly caused by cyclonic disturbances from the Yangtse Valley and Formosa, and is not a simple monsoon rainfall. The period is characterised by con-

tinued cloudy weather, large relative humidity, comparatively high temperature, small wind-velocity, and more or less rainfall every day.—*Nature*, No. 2147.

THE AVERAGE UNIFORMITY OF CERTAIN MARKINGS ON THE PLANET JUPITER.—The equatorial current of Jupiter thus possesses features which, if at times intermittently visible, bear a permanent character. Also the uniformity of such markings has been evinced from a series of continued longitudinal determinations, which have proved that at certain points of the surface the apparently ejected matter from a hidden kernel is displayed, on the average, at regular intervals along either side of the equator. An unprecedented swift axial rotation, such as we perceive in Jupiter, together with his huge bulk, may account for much that is brought to light through a persistent study of the planet. —SCRIVEN BOLTON, in *Journal British Astronomical Association*, No. 1.

NOTES AND QUERIS

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

A Lack of Queries

The Editor would draw the attention of the readers of the JOURNAL to the request, given above, that questions and other interesting matter be sent for use in this department. Difficulties and questions must be continually arising and the discussion of these is always of general interest.

Mr. Bruce's Observatory

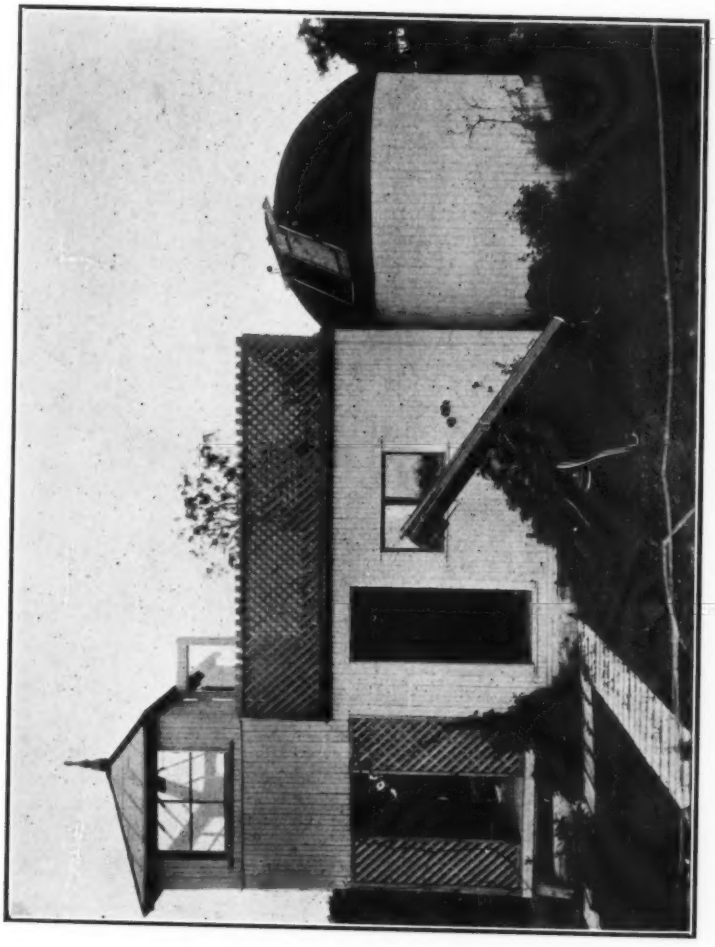
We have much pleasure in presenting a view of the observatory of Mr. Wm. Bruce, vice-president of the Hamilton Centre of our Society, (Plate XXXVI.). A new 3-inch refractor has recently been installed. The optical parts were made by the John A. Brashear Co., of Allegheny, Pa., and the mounting by James and John Marsh, of Springville, Ont. The mounting is creditably done and the definition of the instrument is excellent.

The telescope is mounted on a strong iron pier with equatorial fittings and clock-driving apparatus sufficiently strong and rigid to carry a 6-inch telescope. The circles are 8 inches in diameter. The R. A. circle is graduated to read to one minute of time and the declination circle to five minutes of arc.

This fine instrument is set up and properly housed on the beautiful grounds of Mr. Bruce's residence on the Mountain top, Hamilton, Chedoke, P.O. From this vantage point there is an unobstructed view of the heavens. There are many visitors to the observatory, young and old, (as many as twenty in an evening) who have never looked through a telescope, and Mr. Bruce is certainly doing a splendid work in educating the general public to take an interest in the wonders of the heavens.

Mr. Bruce has now withdrawn from active business life and

PLATE XXXVI.



THE OBSERVATORY OF MR. W. BRUCE, WEST MT. HAMILTON, ONT.

is devoting his entire time to art and astronomical research. The members of the R.A.S.C. will unite in the wish that Mr. Bruce may long be spared to carry on his admirable work.

Newspaper Astronomy

The ordinary citizen would part with his daily newspaper with great regret, and we must allow that the busy reporter has a wonderfully broad and varied knowledge. I suppose we should overlook some of the mistakes made in reporting semi-technical lectures, but some of the errors are very ludicious and betray an extraordinary misunderstanding of the subject described.

A couple copies of newspapers published in one of our ambitious Canadian cities have come into the Editor's possession, which illustrate in a striking manner the remarks just made. In them are reports of a lecture dealing with the surface of the sun, and the following extracts are very edifying and—startling:—

"What are the problems of the sun? There are a great number of problems —the roof, the interior, the size, the mass of the sun, its source of heat and the great problem, its chemical constitution, what is it made of? . . . .

There is a dusk veil surrounding the sun, and that is why it looks like a bowl of rice, or an egg shell. . . .

The photosphere looks like a person's brain, or an egg shell, or a bowl of sugar. These little specks are about 600 miles across, and are sub-divided into little particles, about 100 miles across. There is only about one-fifth of the sun covered with these, and they may be seen on the sun just before rain. . . .

I will say a few words about the chromosphere. It is composed of metals, not found upon our earth. The chromosphere is often from nine to ten thousand miles in thickness. Then there are the forest fires of the sun. . . . The greatest fire known on the sun reached a height of 400,000 miles. . . .

The sun is the only star near enough for us to study, and yet when observed through a telescope appears as only a little dot and by actual measurement at Greenich Observatory the disc of the sun is only thirty-six inches. . . .

In studying the sun it must be studied in parts and it is no easy matter to divide it into parts in order to study it.

The photosphere is divided and sub-divided into two small particles resembling rice and these particles have been found by measurement to be six hundred and one hundred miles across. Only one-fifth of the sun is so divided yet it is from this source that three-quarters of its heat is derived. . . .

He then went on and explained the cause of the aurora borealis or northern lights. When there are two or more bodies of sun spots near each other a magnetic field is set up and extends to the earth and affects terrestrial magnetics and hence the above phenomena. . . .

The sun is not a solid body because there is a continual twist of it all the time. . . .

A large amount of useful information was certainly absorbed by those who heard last night's address.

Wonderful photographs of the sun . . . . as explained in clear, lucid style . . . . proved extremely interesting and instructive."

Nothing is so bad but it might be worse ; and I suppose we can find a crumb of comfort in the knowledge that the subject of astronomy is of such general interest that the newspapers are willing to devote a comparatively large amount of their space to it.

The Royal Astronomical Society of Canada may well extend congratulations to the Astronomical Society of Barcelona.

In a letter addressed to our Librarian, Mr. S. Raurict, the Secretary of the Barcelona Society, states that it is the only astronomical society ever founded in Spain, and that though only recently organised it has already a membership of 230. It also publishes a *Bulletin*, which it expects, in time, to develop in importance. The officers are ambitious that it shall be a credit to the Society and the cause of astronomy which it advocates. These scientific organisations, reaching out from country to country, must surely help forward the earnest efforts which are being made to ensure continued international peace.

The writer learns that one of our Ottawa members, Mr. A. H. W. Cleave, Master of the Mint, desires to dispose of his telescope. It is a five-inch refractor of the highest quality, with equatorial mounting and clock, and with numerous eye-pieces and other accessories. Any one desiring information may write to Mr. Cleave. I may say, also, that Mr. J. R. Collins, Secretary of the R.A.S.C., will be glad, at any time, to assist members wishing to secure instruments. C. A. C.

PREDICTIONS FOR JANUARY AND FEBRUARY

NOTE

It is intended to issue the *Predictions* for 1911 in a separate publication, but this course was decided upon by the Council at so late a date that the publication is not yet ready. It will be sent out to Members as soon as possible.

JANUARY

THE SUN.—On the 1st the right ascension is $18^h\ 43^m$, declination 23° 5′ south. It rises in Toronto at 7.51 a.m. and sets at 4.51 p.m. (E.S.T.) : in Winnipeg, (6 degrees farther north), at 8.26 a.m. and 4.36 p.m., respectively, (C.S.T.).

The earth is nearest the sun on January 3, at which time the sun's apparent diameter is 32′ 36″.

During January the equation of time rapidly rises, changing from 3m 29s on January 1 to 13m 30s on January 31. This effect, taken with the fact that at the beginning of the year the days are lengthening slowly, causes the time of sunrise to appear stationary for ten days or more at the beginning of the year while the time of sunset gradually becomes later.

THE MOON.—The moon's phases are as follows, (E.S.T.).

☽ First Quarter, January 8, 1.20 a.m.
☽ Full Moon, January 14, 5.26 p.m.
☾ Last Quarter, January 22, 1.21 a.m.
● New Moon, January 30, 4.45 a.m.
Perigee, January 12, 7 p.m.
Apogee, January 24, 3 p.m.

The Planets

Mercury is in inferior conjunction with the sun on January 10th. After that it is a morning star, on the 31st rising about 1½ hours before the sun. On February 2nd it has its greatest elongation west, 25° 18′. Its declination then is 21° 31′ south.

Venus is an evening star in Capricorn. On January 1st its R.A. is 19^h 23^m, declination 23° 8′ south; on January 31, R.A. 21^h 57^m; declination 14° 5′ south. On this latter date it sets about an hour after the sun. The planet is not well placed for observations during the month.

Mars is a morning star, being visible in the south-east for a short time before sunrise. During the month it passes into Sagittarius. It is inconspicuous and is not well placed for useful observation.

Jupiter is a bright object in the morning sky in Libra. It crosses the meridian on January 15th at 7 a.m. On that date its R.A. is 14^h 38^m, declination 14° 12′ south. The moon is in conjunction with Jupiter on January 23rd, 1.48 a.m. (E.S.T.), at which time the planet is 57′ north of the centre of the moon.

Saturn on January 15th comes to the meridian at 6.18 (M.T.) and is thus well-placed for observation. The rings are gradually opening out at present. Saturn can be seen even with very modest telescopes. The planet is a beautiful object. The moon is in conjunction with Saturn at midnight on the 8th the planet being 1° 4′ south of the centre of the moon.

Uranus is in Sagittarius. It will be in conjunction with the sun on January 16th, and so will not be observable during the month.

Neptune is in Gemini, and will be in opposition to the sun on January 11, that is, at that time it will be on the meridian at midnight. The planet can scarcely be identified in a small telescope.

Objects for a Small Telescope

The constellations best seen in January are Camelopardalis (the Giraffe), Auriga (the Charioteer), Taurus (the Bull) and Orion. In these the following objects are of great interest :—

DOUBLE STARS.—*β Orionis* (Rigel) ; mags. 1, 8 ; distance 9″. Rather difficult in small telescopes on account of brilliancy of the greater component.

δ Orionis ; mags. 2, 7 ; distance 53″ ; white and pale violet.

λ Orionis ; mags. 4, 6 ; distance 4″·2 ; pale yellow and purplish.

θ Orionis ; the Trapezium in the densest part of the Great Nebula. Four stars : mags. 6, 7, 7·5, 8.

ζ Orionis ; in ordinary telescopes, "a double-treble star, or two sets of treble stars similarly situated."—Herschel.

NEBULÆ AND STAR CLUSTERS

*Clusters and Nebulæ.—M.*37 in Auriga, about 12° north of *β* Aurigæ. A fine cluster, even in small instruments very beautiful.

*The Great Nebula in Orion, M.*42 ; the finest of all nebulæ.

*The Crab Nebula in Taurus, M.*1 ; accidentally discovered by Messier in 1758.

FEBRUARY

THE SUN.—On February 1 the sun's R. A. is $20^h\ 56^m$, declination 17° 20′ south. In Toronto it rises at 7.36 a.m., sets at 5.28 p.m. (E.S.T.); in Winnipeg, at 8.03 a.m. and 5.21 p.m., respectively (C.S.T.).

During February the equation of time rises to a maximum 14m 25s (February 12) and then falls to 12m 52s on February 28.

THE MOON.—The moon's phases are as follows, (E.S.T.).

☽ First Quarter, February 6, 10.28 a.m.
☽ Full Moon, February 13, 5.38 a.m.
☾ Last Quarter, February 20, 10.44 p.m.
☽ New Moon, February 28, 7.31 p.m.
Perigee, February 9, 12 noon.
Apogee, February 21, 12 noon.

THE PLANETS

MERCURY, as stated above, reaches its greatest elongation west on February 2, attaining a distance of 25° 18′ from the sun.

It is in declination 21° 29′ south then, and so is not well placed for observation.

VENUS during the month crosses Aquarius and gets well into Pisces. It remains an evening star, setting about 1¾ hours after the sun. On February 28 its declination is 1° 31′ north of the equator and hence its position for observation is much improved ; but the brilliancy of its disc is not very great.

MARS, on February 28, crosses the meridian at 8.59 a.m. (M.T.), slowly separating from the sun, but it still remains an inconspicuous object.

JUPITER remains a bright morning star. It crosses the meridian on February 28 at 4.22 a.m. (M.T.). On February 3 it is in quadrature with the sun, and on the 19th at 1.14 p.m. it is in conjunction with the moon, being 1° 31′ north of the centre of the moon. On March 1 it reaches a stationary point.

SATURN on February 15 crosses the meridian at 4.22 p.m. (M.T.), but it can still be well observed in the evening. On the 5th it is in conjunction with the moon, the planet being 1° 18′ south of the centre of the moon.

URANUS still remains too near the sun to be observed. On February 15 it crosses the meridian at 10.19 a.m.

NEPTUNE will be in conjunction with the moon on the 10th at 6.32 p.m. (E.S.T.), the planet being 5° 13′ south of the centre of the moon.

OBJECTS FOR A SMALL TELESCOPE

In February the constellations best seen are Canis Major (the Great Dog), Canis Minor (the Lesser Dog), and Gemini (the Twins).

DOUBLE STARS.—α *Geminorum* (Castor) ; mags. 2·7, 3·7 ; distance 5″·8. The largest and finest double in our hemisphere.

δ *Geminorum* ; mags. 3·2, 8·2 ; distance 7″·1 ; white and purple ; rather difficult double.

κ *Geminorum* ; mags. 4, 9 ; distance 6″·3 ; very delicate and beautiful.

THE

ROYAL ASTRONOMICAL SOCIETY OF CANADA

LIBRARY CATALOGUE

TORONTO: 1911

DIVISION I.—Bound Periodicals

ANNUAL RECORD of Science and Industry: 1872.

ASTRONOMICAL JOURNAL: Vols. xxii.-xxv. (In progress).

ASTRONOMICAL REGISTER: 1868 to 1872 (inclusive) and 1880 to 1886 (inclusive).

ASTRONOMISCHE MITTEILUNGEN, Zurich: 1876 to 1895. (In progress).

ASTRONOMISCHE RUNDSCHAU: Vols. iii.-x. (inclusive), 1901-8.

ASTRONOMY AND ASTROPHYSICS (previously Sidereal Messenger): Vols. xi.-xiii., also General Index.

ASTROPHYSICAL JOURNAL: Vols. i.-xxviii. (inclusive) 1895-1908. General Index: Vols. i.-xxv. (In progress).

CANADIAN MAGAZINE: 1871 to 1873.

CAMBRIAN NATURAL OBSERVER: Astronomical Society of Wales: Vols i.-vi. and x, 1890-1903 and 1907-8. (In progress).

FRANKLIN INSTITUTE, "Journal": Vols. cl.-cliv., clvii.-clix. and clxii.-clxv. (In progress).

JOURNAL of Arts and Manufactures, Upper Canada: 1863-4.

KNOWLEDGE: (in progress) Vols. i.-iv.; v. (2 copies), vii., xv., xvi. and xvii. (2 copies), xviii.-xxvi. and New Series Vols. i.-iii. (inclusive).

MONTHLY WEATHER REVIEW, U. S.: 1893 to 1908.

NEWSPAPER CUTTINGS: Andrew Elvins: 2 Vols.

OBSERVATORY: (in progress) Vols. xxiv.-xxxii., (1901 to 1909).

PHOTOGRAPHIC NEWS, The: 1863, 1864.

POPULAR ASTRONOMY: (in progress) Vols. i.-xvi, 1893-1908. General Index to Sidereal Messenger, Astronomy and Astrophysics, and to Popular Astronomy, Vols. i.-xvi.

PUBLIC WORKS—Canada—Annual Report of Minister of, 1887-8, 1889-90.

REPORT of the U. S. Secretary of Agriculture : 1890.
SCIENCE : Vols. iii. and iv.
SIDEREAL MESSENGER (continued as Astronomy and Astrophysics) : Vols. i.- x. inclusive. General Index : Vols. i.- x.

DIVISION II.—Reports of Learned Societies and Institutions

AMERICAN Academy of Arts and Sciences. Proceedings : Vols. xxxiv., xxxvi.- xliii.

AMERICAN Association. Proceedings : Vols. xxxi., xxxiii. and xl.- xlix.

AMERICAN Philosophical Society, Philadelphia. Proceedings : Vol. xlviii. and Vol. xlix., January-September.
List of Members, 1910.

ASTRONOMICAL Society of the Pacific, Publications : Vols. i.- xix.
ASTRONOMICAL Society of Wales, Journal : Vols. i, ii.
ASTRONOMICAL and Physical Society of Toronto. Transactions: 1890-1905, bound in duplicate. (See also Royal Astronomical Society of Canada).

ASTRONOMICAL and Astrophysical Society of America. Reports of Meetings (unbound).

BRITISH Association for the Advancement of Science. Reports : 1833, 1835, 1838, 1858, 1866-68, 1884, 1897 (2 copies) 1898-1900, 1902-8. (See also Div. XVI.).

BRITISH Astronomical Association. Journal : Vols. i.- xix., and General Index : Vols. i.- xviii.
Memoirs : Vols. i.-xv.

CANADIAN Institute Publications : 1852-1909.
Canadian Journal : Vols. i. (Nos. 1-5 and 9-12), ii., iii. (4to).
Canadian Journal : Vols. i.- x. and xii.- xv. (8vo ed.)
Proceedings : Vols. i., Parts 1 and 3 (unbound), ii., iii. ; iv. Fasc. 1 (unbound), and v.- vii.
Proceedings, New Series : Vols. i. and ii.
Transactions : Vols. i.- vii., (inclusive).

CHICAGO Academy of Sciences. Bulletin : Vols i.-ii. ; iii., Nos. 1-3, and Vol. vii., Part 1.

HAMILTON ASSOCIATION. Journal and Proceedings : 1882-3, 1889-96, 1901-2, 1902-3, 1907-8.
Proceedings of the Jubilee Celebration, November 8, 1907.

JOHN CRERAR Library : Annual Report, 1906-9.
List of Books in the Reading Room, 1909.
List of Books exhibited December 30, 1907 to January 4, 1908.
Hand Book for 1907.
A List of Current Medical Periodicals and Allied Serials, 1909.

LAVAL UNIVERSITY. Annuaire, 1908-9, 1909-11.

LEEDS Astronomical Society. Journal and Transactions: 1893-1901, 1903-1906, 1909.

MICHIGAN Academy of Science. Reports: 1903 and 1905-1909.

NATURAL History Society of New Brunswick. Bulletin: 1885-96 (bound), Vol. v. Part 5, and Vol. vi., Parts 1 and 2.

NEW YORK Academy of Sciences. Annals: Vols. viii.- xi.; xii. (Parts 2 and 3), xiii.- xviii.; xix. (Parts 1 and 2).
Transactions: Vols. xiv.- xvi. Memoirs: Vol. i., Parts 1 and 2.

NOVA SCOTIAN Institute of Science. Proceedings and Transactions: Vol. i., Second Series; Vol. ii. Parts 1-4; Vol. xii. Part 1.

ONTARIO Educational Association. Proceedings: 1897-8.

PHILOSOPHICAL Society of Washington. Bulletin: Vols xiii. and xiv., Vol. xv. (incomplete), and unbound sections.

ROCHESTER Academy of Science. Proceedings: Vols. iii. and iv. (incomplete).

ROYAL Astronomical Society. Monthly Notices: Vols. x.- lxix. inclusive. General Index: Vols. i.- lii.
Memoirs: Vols. v.-lvii. (bound), Vols. lviii., lix., Parts 1-4, (unbound). General Index: Vols. i.-xxxviii. and xxxix.- liv.

ROYAL Astronomical Society of Canada (see Div. IV.). Journal: Vols. i.- iii., Vol. iv. Nos. 1 to 5. (See also Astronomical and Physical Society of Toronto).

ROYAL Society of Canada. Proceedings and Transactions: Vols. i.- xii.. Second Series: Vols. i.- xii. Third Series: Vols. i. and ii. General Index to First and Second Series.

ROYAL Society of Edinburgh. Proceedings: Vols. xx.- xxii., xxiv., xxvi.- xxviii.

ROYAL Society of London. Proceedings: Vols. i.- lxxxi. inclusive.

ROYAL Society of Queensland. Proceedings: Vols. xx.- xxi; xxii. (Part 1).

ST. LOUIS Academy of Science. Transactions: Vols. xvi. (parts 8 and 9), xvii. (parts 1 and 2), xviii. (part 1).

SMITHSONIAN Institution. Reports: 1879, 1880, 1889, 1890. (See also Division III.)

SOCIETÀ degli Spettroscopisti Italiani. Memorie: Vols. xxiii.- xxxvii. (inclusive).

SOCIÉTÉ Astronomique de France. Bulletin: 1902-4, 1906-8.

SOCIÉTÉ Belge d' Astronomie. Bulletin: 1903-1908.

SPECOLA VATICANA. Pubblicazion: Vols. i.- v. Catalogo Fotografico Stellare: Vol. i.

UNIVERSITY of Illinois Studies. Bulletin: Vol. iv., No. 25.

WISCONSIN Academy of Sciences. Transactions: Vols. x.- xiv.; xv., part 1 and 2; xvi., part 1, Nos. 1-6 (unbound).

DIVISION III.—Publications of Observatories

ABBADIA OBSERVATORY. Observations with Meridian Circle: Vols. i.- viii.

ALGER OBSERVATORY: Catalogue Photographique du Ciel: n troduction; Tome v., Fasc. 1; vi., Fasc. 1 and 2; vii., Fasc. 1.

ALLEGHENY OBSERATORY. Miscellaneous Scientific Papers: New Series, Nos. 1-20.

BORDEAUX OBSERVATORY. Catalogue Photographique du Ciel: Vols. i., ii*a*., ii*b*.

CAMBRIDGE OBSERVATORY. Annual Report of the Observatory Syndicate: 1904, June 1—1905, April 30; 1906, May 19—1907, May 18; 1907, May 19—1908, May 18; 1908, May 19—1909, May 18.

Observations: Vol. xxiv., part 1.

CAPE OBSERVATORY, Cape of Good Hope. Annals: Vols. iii.-vii. and ix.

Report of His Majesty's Astronomer: 1895 to 1907, and 1909.

Independent Day Numbers: 1897, 1901, 1905-1909.

Cape Catalogue: 1885-1895, 1905-6.

Cape General Catalogue: 1900.

Cape Catalogue of Astrographic Standard Stars: 1900.

CHEVREUSE OBSERVATORY. Meteorologie: 1903-1905.

CHICAGO UNIVERSITY Decennial Publications. Measures of Double Stars: Yerkes Observatory in 1900 and 1901.

The Spectra of Stars of Secchi's Fourth Type: Yerkes Observatory, 1903.

Photography with Forty-Inch Refractor and Two-Foot Reflector: Yerkes Observatory, 1904. (See also Yerkes Observatory).

CINCINNATI OBSERVATORY. Publications: 1878-86; 1887, 91-2; and unbound Nos. 13 to 16.

COLORADO COLLEGE Studies and Publications.

Engineering Series: Vol. i., Nos. 3 and 4.

Language Series: Vol. ii., Nos. 18-21.

Science Series: Vol. xi., Nos. 33-53.

COLUMBIA UNIVERSITY Observatory. Contributions: Nos. 1-3, 6-9, 11-17, 19-27.

DOMINION ASTRONOMICAL Observatory. Record of the Earthquake Station: Nos. 1-10.

Report of the Chief Astronomer: 1905-1908.

DUNSINK OBSERVATORY. Astronomical Observations and Researches: Part 8.

ENCYCLOPÆDIA BRITANNICA.

FLOWER ASTRONOMICAL Observatory. (See University of Pennsylvania).

GEODETIC SURVEY of South Africa.
Vol. i., Report of Survey Cape of Good Hope.
Vol. ii.; Report of Survey Cape of Good Hope.
Vol. iii., Report of Survey in Rhodesia.
Vol. v., Report of Survey in Transvaal and Orange River Colony.

GEORGETOWN COLLEGE OBSERVATORY. Observations:
Vol. i., First Chart and Catalogue for Observing Novi Persei.
Vol. ii. Second Chart and Catalogue for Observing Novi Persei.
Vol. iii., Chart and Catalogue for Observing Nova Geminorum.
Vol. iv., Preliminary Light Curve of Nova Persei from February 22 to May 1, 1901.
Vol. v., Observations of Variable Stars made in the years 1884-1890.
Vol. vi., Supplementary Notes to the Atlas Stellarum Variabilium.

GREENWICH OBSERVATORY. (See Royal Observatory).

HAMILTON COLLEGE Observatory. Heliographic Positions of Sun-Spots Observed by Dr. C. H. Peters from 1860 to 1870.

HARVARD COLLEGE OBSERVATORY. Annals (bound): Vols. xii., xiii., xv.-xix,, xxi.-xlvi, xlviii.-li., lviii., lx.
Annals (unbound): Vols. xi., Part 2; xx., Part 2; xlvii., Part 1; lii., Part 1 and 2; liii.-lv., Part 1 and 2; lvi., Parts 1-4; lvii., Part 1 and 2; lix., Parts 1-5; lxi., Parts 1 and 2; lxii., Part 1; lxiv., Nos. 1-6; lxviii. No. 1; lxix., No. 1; lxx.
Circulars: Nos. 1 to 100 (bound).
Report of Director: Nos. 37-54, 56-64.
Telegraphic Cipher Code.
Miscellaneous Papers: 1888-1895.
Bulletin for years 1902-1905.

HAUTE-GARONNE. (See Toulouse Observatory).

INSTITUTE de France Académie des Sciences. Conférence Astrophotographique internationale de Juillet, 1900.
Circulaires, Nos. 9, 10, 12.
Réunion du comité international permanent pour l' éxécution de la carte photographique du ciel tenue á l' Observatoire de Paris en Mai 1896, 1900.
Extraits des Comptes rendus des Séances de l' Académie des Sciences: Vols. cxxxvi, page 1505, June, 1903; cxxxv., page 73, July, 1902; cxxix., July 3, 1899; cxxviii., June 26, 1899. (See also Abbadia Observatory).

KAISERL. Leop.-Carol. Deutschen Akademie der Naturforscher: Band lxxxv., No. 2.

KEW OBSERVATORY. (See National Physical Laboratory).

KIEL OBSERVATORY. Publications: Vols. i.-v.; vi., (Part 2), vii., (Part 1), viii.-xii.

KÖNIGSTUHL-HEIDELBERG Observatory. Publikationen: Vol. i.

LEANDER MCCORMICK Observatory. Publications: Vol. i., Parts 1, 3-7.

LEHIGH UNIVERSITY. Astronomical Papers: Vol. i, Part 1.

LICK OBSERVATORY. Bulletin: 1901-2, 1902-4, 1904-5, 1905-8.
Publications: Vols. i.-vi., viii., ix., Parts 1-3, x.
Report of Observations made on Mount Hamilton.
Report to the Trustees of the "James Lick Trust."
Reports on the Observations of Total Eclipse of the Sun, December 21-22, 1889; January 1, 1889.
Contributions: Vols. iii.-v.

LISBON ROYAL Observatory. Observations of Eclipses of the Moon at the Royal Observatory of Lisbon.
Corrections of the Right Ascensions of some Stars in the Berlin Year Book.
Meridian Observations of the Planet Mars during the Opposition of 1892.

LOWELL OBSERVATORY. Annals: Vols. i.-iii.

MADRAS OBSERVATORY. Taylor's General Catalogue of Stars for the Equinox, 1835·0. (See also Div. IV.)

MANILA CENTRAL Observatory. Bulletin of the Weather Bureau: 1904-1908, 1909, 1910, January to May.
Annual Report: 1903, Parts 1-3; 1904, Parts 1-3; 1905, Parts 1 and 2; 1906, Part 1; 1907, Part 1.
Catalogue of Violent and Destructive Earthquakes in the Philippines: 1599-1909.
Mirado Observatory, Baguio, Benquet, a new Meteorological-Geodynamic Station of the Weather Bureau.

MANILA METEOROLOGICAL Observatory. El Magnetismo-Terrestre en Filipinas.

MOUNT WILSON Solar Observatory. Contributions: 1 to 28.
Some Opportunities for Astronomical Work with Inexpensive Apparatus: Geo. E. Hale.

NATIONAL PHYSICAL Laboratory (Kew Observatory). Reports of Observatory Department: 1901 to 1909.

NICE OBSERVATORY. Annales: Vols. i.-vi. inclusive. Atlas accompanying Annales Vols. i. and iii.

OBSERVATOIRE ROYAL de Belgique. Annales: Vols. ix., Nos. 2 and 3; x., xi., Nos. 1 and 2; xii., Part 1.
Serie, Physique du Globe: Vol. iii., No. 3.
Annuaire Astronomique pour 1907.

PARIS OBSERVATORY. Rapport Annuel: 1892-95, 1897-1905, 1907-1909.
Catalogue Photographique du Ciel: Vol i. and ii.
Atlas Photographique de la Lune; Planches i.-xli. and xlviii.-liii.; also "A" to "G" and "I."
Atlas Photographique de la Lune: Fascicules 1 and 2.

POTSDAM ASTROPHYSICAL Observatory. Publications: Vols. vii., Part 1; xv., Part 2; xx., Parts 2-4; xix., Part 1.
Photograph. Himmelskarte. Katalog. Ergänzungen und Berichtigungen zu den Bd. 1, bis iv.

ROUSDON OBSERVATORY, Devon. Meteorological Observations: 1900, Vol. xvii.
Astronomical Observations: 1882-5.
Variable Star Notes: Nos. 2-6.

ROYAL ALFRED Observatory, Mauritius. Results of the Magnetical and Meteorological Observations for the years 1896, 1898-1906.
Annual Report of the Director: 1896-7, 1899, 1903, 1905-8.
Mauritius Magnetical Reductions: (Published 1899).

ROYAL OBSERVATORY of Belgium. (See Observatoire Royal de Belgique).

ROYAL OBSERVATORY, Edinburgh. Astronomical Observations: Vol. xii., (1855-59).

ROYAL OBSERVATORY, Greenwich.
Observations: 1889-1907 and Appendix.
Astrographic Catalogue: 1900·0; 1900, Vol. ii.
Groombridge's Catalogue of Circumpolar Stars, 1810·0.
Determinations of Longitude: 1888-1902.
Reduction of Greenwich Meteorological Observations: Parts 3 and 4.
Photo-heliographic Results 1874-1885.
Observations of Eros 1900-1 for Determination of Solar Parallax.
Greenwich Second Nine-Year Catalogue of Stars for 1900.

SMITHSONIAN INSTITUTION. Annals of Astrophysical Observatory: Vols. i. and ii. (See also Div. II.)

TACUBAYA, Observatorio Astronomico Nacional, Mexico.
Annuair: 1908-10.
Observaciones Meteorológicas Practicadas at Tacubaya y Cuajimalpa in 1904, and during the year 1897.

TOKYO OBSERVATORY. Annales: Vol. ii., Part 1; iii., Parts 2-6; iv.

TOULOUSE OBSERVATORY. Annales: Vols. i.-v. and vii.
Catalogue Photographique du Ciel: Vols. ii., Part 1; iv., Part 1; vi., Part 1; vii., Parts 1 and 3.
Bulletin de la Commission Météorologique du department de la Haute-Garonne: Tome i., 1901-5; Tome ii., Parts 1 and 2.

UNIVERSITY of Pennsylvania, Flower Astronomical Observatory.
Publications: Vols. i., Parts 2 and 3; ii., Parts 1-3; iii., Parts 1 and 3.

U. S. COAST and Geodetic Survey. Reports: 1890, appendices Nos. 8 and 9; 1895, appendix No. 1.

U. S. NAVAL Observatory, Washington.
Observations: 1851-2, 1863-4, 1868-70, 1872-3, 1875, 1876, Parts 1 and 2 ; 1877-1890, appendix for 1890 ; 1891-2.
Magnetic Observations : 1888-9.
Publications : Vols. i.-iii., iv., Parts 1-3 ; iv., Part 4 ; (appendix 1, and v.)
Equatorial Reduction Tables.
Superintendent's Report : 1901-6, 1908-9.
Transit of Venus Papers : Parts 1 and 2 with atlas to Part 2 ; and Part 3, being Newcomb's "Tables of the Moon."

UTRECHT OBSERVATORY. Recherches Astronomiques : Tome iii.

VASSAR COLLEGE Observatory. Publications : No. 1.

WASHBURN OBSERVATORY. Publications : Vols. ii.-v., vi., Parts 1-4 ; vii., Parts 1 and 2; viii., ix., x., Parts 1-3 ; xi., xii.

WASHINGTON OBSERVATORY. (See U. S. Naval Observatory).

WEST HENDON HOUSE Observatory. Publications : Nos. 2 and 3.

YALE OBSERVATORY. Transactions : Vols. i., ii., Part 1.

YERKES OBSERVATORY. Publications : Vols. i., ii.; iii., Part 1. Bulletins : 1, 2, 4-19. (See also Chicago University).

ZURICH OBSERVATORY. Publications : Vols. i.-iv.

DIVISION IV.—Almanacs, Tables, Star Charts, and Catalogues

SECTION CATALOGUED UNDER AUTHOR

ALGUÉ, Rev. José. "The Cyclones of the Far East." 2nd rev. ed. Manila 1904.

BAILY, Francis. "Astronomical Tables and Formulæ. 1827.

BURNHAM, S. W. "A General Catalogue of Double Stars within 121° of the North Pole." Vols. i. and ii.

BURRITT. "Atlas designed to illustrate Burritt's Geography of the Heavens." 1856.

CARRINGTON, Richard C. "Catalogue of 3735 Circumpolar Stars observed at Redhill in the years 1854-55 and 1856 and reduced to mean positions for 1855·0."

CHANT, C. A., "The Canadian Astronomical Handbook," 1907, 1908.

CLARK, Latimer ; and SADLER, Herbert. "Star-Guide." 1886.

COFFIN, Professor J. H. C. "Star Tables of the American Ephemeris. 1869.
"Tables to Facilitate the Reduction of Places of the Fixed Stars." Second ed. 1873.

COTTAM, Arthur. "Charts of the Constellations." With Introduction and Notes. 1891.

CROSSLEY, Edward ; GLEDHILL, Jos. ; and WILSON, J. M. "A Handbook of Double Stars." 1879.

FLAMMARION, Camille. "Annuaire Astronomiquê et Meteorologique pour 1902."

"Atlas Astronomique de poche. . . . contenant 18 cartes et explications."

FORCE, Peter. "Record of Auroral Phenomena Observed in the Higher Northern Altitudes." 1856.

HALL, Maxwell. "The Rainfall of Jamaica"—thirteen maps showing the average rainfall in each month and during the year. 1892.

HILDERBRANDSSON, H., and others. "International Cloud Atlas." 1896.

HILL, Geo. W. "Tables of Venus." 1872.

KELLY, P. "Astronomical Computations": comprising new tables, etc. 1812.

KLEIN, Hermann J. "Star Atlas." 1893.

GEELMUYDEN, H., and SCHRŒTER, J. Fr. "Meridian—Beobachtungen von Sternen in der Zone 65°-70° Nordlicher Declination." 1909.

GREENWOOD, W. Nelson. "Kludonometric Tide Tables, etc." 1895-1904.

LEON, Luis G. "Catalogs de Nebulosas y Masas Estelares, etc." (2 copies). 1903.

LŒWY, M. M., and PUISEUX, M. P. "Atlas Photographique de la Lune." 1896.

LITTLEHALES, G. W. "The Progress of Science as Exemplified in Terrestrial Magnetism." 1905.

MAYER, Tobias, and MASON, Charles. "Tables of the Motion of the Sun and Moon." 1770.

"Lunar Tables improved." 1787. (bound together).

MIREMONT, Comte de. "Popular Star Maps."

NEWCOMB, Simon. "Catalogue of 1098 Standard Clock and Zodiacal Stars."

"Astronomical Constants." 1895.

"The Uranian and Neptunian Systems investigated. . . . Washington Observations 1873. (app. 1).

"Researches on the Motion of the Moon." Washington Observations 1875, app. 2.

PEIRCE, Benjamin. "Tables of the Moon." 1865.

POOLE, Bros. "Celestial Handbook." Compiled by Jules A. Colas. 1892.

PROCTOR, Richard A. "Star Atlas." Ed. 5, 1886; ed. 12, 1887.

SCHOTT, Charles A. "Atmospheric Temperature Tables." (Smithsonian) 1876.

"Tables and Results of the precipitation in rain and snow in the U.S." 1872.

SCHUBERT, E. "Tables of Eunomia." 1866.
"Tables of Parthenope." 1871.
"Tables of Melpomene." 1860.
TROMHOLT, Sophus. "Catalog der in Norwegen bis Juni, 1878, Beobachteten Nordlichter. 1902.
UPTON, Winslow. "Star Atlas," with explanatory text. 1896.
WINLOCK, Joseph. "Tables of Mercury." 1864.

GENERAL CATALOGUE OF DIVISION IV.

AMERICAN Coasters' Almanac for 1884.
AMERICAN Ephemeris and Nautical Almanac: 1866, 1870-1884, (supplement to 1884), 1885, 1886 (supplement to 1886), 1887-1911.
Star List of the American Ephemeris, 1909.
Stars for Navigators and Polaris Tables for 1910.
Star List of the American Ephemeris for 1910. (See also Astronomical Papers of the American Ephemeris).
AMERICAN Nautical Almanac for 1893.
ASTROGRAPHIC Catalogue 1900.0. The Oxford Section: Vols. i.-vi. (inclusive).
ASTRONOMICAL Figures. Illustrations of the Earth's Form; Solar System, etc."
ASTRONOMICAL Papers of the American Ephemeris. Vols. i., Parts 2, 3, 5, 6; ii.-viii. inclusive.
ATLANTIC Coaster's Almanac: 1885 to 1892—all in duplicate.
BERLINER Astronomisches Jahrbuch. 1896-7, 1899-1912.
CHRISTIANIA Observatory. (See Geelmuyden and Tromholt.)
DEPARTMENT of Marine and Fisheries, Canada. (See Meteorological Service.
GREENWOOD'S Tide Tables. 1895-1904 inclusive.
HICKS' Almanac. 1894-7.
ILLUSTRATED London Almanac. 2 Vols. 1850-62, 1863-72.
MADRAS Observatory. Taylor's General Catalogue of Stars for the equinox 1835.0 from Observations made in Madras Observatory during the years 1831-42. Revised and edited by A. M. W. Downing. 1901.
METEOROLOGICAL SERVICE of the Dominion of Canada.
Reports: 1874-77, 1888-9, 1895-1903, 1905-6.
Clouds Observations: 1896-7.
NAUTICAL Almanac. 1844, 1851, 1855, 1857, 1859-61, 1863-7, 1869, 1870 (2 copies), 1872-3, 1875, 1877, 1879-80, 1883, 1886-90, (2 copies), 1891-2, 1895-1910, appendices to 1911, 1912 and 1913.
OXFORD University Observatory. (See Astrographic Catalogue).
PACIFIC Coaster's Almanac. 1885-6, 1888, 1890-1901, 1903-5.

PARIS Observatory. Atlas Photographique de la Lune: Parts 1 to 7, 9 and 10. (See also Div. III.)
ROYAL Astronomical Society of Canada. Photographs.
WHITTAKER'S Almanac. 1897, 1900, duplicate; 1901, duplicate.

DIVISION Va.—General Treatises, Text-Books

ADAMS, George. "Astronomical and Geographical Essays." London, 1789.
AIRY, Sir George Biddell. "Popular Astronomy:" A series of lectures delivered at Ipswich. London, 1891.
BALL, Sir Robt. "The Story of the Heavens." 1883.
BOWERS, J. E. "Suns and Worlds of the Universe: outlines of Astronomy according to the philosophy of Emanuel Swedenborg." 1899.
BROWN, Robert. "Researches into the origin of the primitive constellations of the Greeks, Phœnicians and Babylonians." 2 Vols. 1899.
CHAMBERS, Geo. F., "A Handbook of Descriptive and Practical Astronomy." 4th edition, 3 Vols. 1889-90.
"Descriptive Astronomy." 1867.
CLARKE, C. C. "The Wonders of the Heavens, displayed in twenty lectures." 1821.
COMSTOCK, Geo. C. "A Text-Book of Astronomy." 1901.
DICK, Thomas. "Celestial Scenery." 1888.
DOLMAGE, Cecil G. "Astronomy of To-Day." 1909.
FERGUSON, James. "Astronomy explained upon Sir Isaac Newton's Principles." 1778. Another edition with Notes by Sir David Brewster. 2 Vols. 1817 and 1841.
FLAMMARION, Camille. "Popular Astronomy." Translated by J. E. Gore. 1897.
GILLETT, J. A. and ROLFE, W. J. "Astronomy for .... Schools, etc." 1862.
GODFRAY, Hugh. "A Treatise on Astronomy." 4th ed. 1886.
GORE, J. Ellard. "The Visible Universe." 1893.
"An Astronomical Glossary." 1893.
"Studies in Astronomy." 1904.
GUILLEMIN, Amédée. "The Heavens: an illustrated Handbook of Popular Astronomy." Edited by J. N. Lockyer and R. A. Proctor. 1883.
GUY. "Elements of Astronomy and an abridgment of Keith's new treatise on the use of the Globes." 30th edition. 1860.
HAMILTON, Joseph. "Our Own and Other Worlds." 1903.
HAMILTON, J. C. "The Great Centre: an Astronomical Study." 1892.

HENDERSON, Rev. Alex. C. "Popular Introduction to Astronomy." 1905.

HERSCHEL, Sir J. F. W. "Outlines of Astronomy." Two copies. 1860 and 1887.

HOLDEN, Edward S. "The Earth and Sky." 1901.
"Elementary Astronomy." 1899.

HOWE, Herbert A. "A Study of the Sky." 1897.

LANGLEY, S. P. "The New Astronomy." 1889.

LARDNER, Dion. "Popular Astronomy." 1856.
"Handbook on Natural Philosophy and Astronomy." 1858.

LOOMIS, Elias. "Treatise on Astronomy." 1887.

MAILLARD, Louis. "Cours d' Astronomie." Tome i. 1906.

MAIN, Robert. "Rudimentary Astronomy." 1874.

MITCHEL, O. M. "The Orbs of Heaven."
"Popular Astronomy." 1860.
"Popular Astronomy." Revised edition.

MOULTON, F. R. "An Introduction to Astronomy." 1906.

NEWCOMB, Simon. "The Stars: a study of the Universe." 1902.
"Astronomy for everybody." 1903.

NEWCOMB, Simon, and HOLDEN, Edw. S. "Astronomy." 6th edition. 1889.

NORTON, Wm. A. "Elementary Treatise on Astronomy." 1845.

OLMSTED, Denison. "Letters on Astronomy." 1848.
"Introduction to Astronomy." 2 copies. With supplement by E. B. Mason, 1854; and another edition 1844

POOR, Chas. Lane. "The Solar System." A study of recent observations. 1908.

PROCTOR, Richard A., and RANYARD, A. Cowper. "Old and New Astronomy." 1892.

TAYLOR, Henry. "A System of the Creation of Our Globe." 9th edition, revised and enlarged. 1836.

THORNTON, John. "Physiography." Advanced. 1901.

TODD, David P. "A New Astronomy." 1897.

TURNER, H. H. "Modern Astronomy." 1901.

VINCE, Rev. S. "Complete System of Astronomy." 2 Vols. 1797.

WALLACE, Alfred Russel. "Man's Place in the Universe." 1903.

YOUNG, Charles A. "Elements of Astronomy: a text-book." Revised edition. 1897.
"A Text-book of General Astronomy for Colleges and Scientific Schools." 1898.
"Lessons in Astronomy." Revised edition. 1903.
"Manual of Astronomy." 1909.

DIVISION Vb.—Bibliography, History

AIRY, Sir George Biddell. "Autobiography." Edited by Wilfrid Airy. 1896.

ASTRONOMISCHER Jahresbericht. (See Wislicenus).

BAILY, Francis. "An Account of the Rev. John Flamsteed, the first Astronomer Royal, compiled from his own manuscripts and other authentic documents never before compiled . . . his catalogue of Stars," 1835.

BALL, Sir Robert. "Great Astronomers." 1895.

BERRY, Arthur. "History of Astronomy." 1898.

BLARE, John F. "Astronomical Myths," based on Flammarion's "History of the Heavens," 1877.

CAMPBELL, Lewis. "Life of James Clerk Maxwell, with selections from his correspondence and occasional writings." 1884.

CLERKE, Agnes M. "The Herschels and Modern Astronomy." 1901.

"History of Astronomy during the Nineteenth Century." 2nd edition. 1887.

CORTIE. A. L. "Father Perry, the Jesuit Astronomer." 1890.

DREYER, J. L. E. "Tycho Brahe." 1890.

FAHIE, J. J. "Galileo:" his life and works. 1903.

GLAZEBROOK, R. T. "James Clerk Maxwell and Modern Physics." 1901.

GRANT, Robert. "History of Physical Astronomy." 1852.

HALL, Angelo. "An Astronomer's Wife." (The biography of Angeline Hall). 1908.

HOLDEN, Edward S. "Stories of the Great Astronomers." 1901.

LOCKYER, Sir Norman. "Stonehenge and other British Stone monuments, astronomically considered." 1906.

LODGE, Sir Oliver. "Pioneers of Science." 1893.

LOOMIS, Elias. "Recent Progress of Astronomy." 1856.

MACPHERSON, Hector. "A Century's Progress in Astronomy." 1906.

MAUNDER, E. W. "The Astronomy of the Bible." 2nd edition. 1908.

"The Royal Observatory Greenwich." 1900.

MCKENDRICK, John Gray. "Hermann Ludwig Ferdinand von Helmholtz." 1899.

NEWCOMB, Simon. "Reminiscences of an Astronomer." 1903.

SALMON, Rev. S. D. F., and others. "Christian Men of Science."

SCHIAPARELLI, Giovanni. "Astronomy in the Old Testament." 1905.

THOMPSON, Silvanus P. "Michael Faraday, His Life and Work." 1901.

TURNER, H. H. "Astronomical Discovery." 1904.
WISLICENUS, Walter F. "Astronomischer Jahresbericht." Vols. i.-xi.

DIVISION VI.—Spherical Astronomy, Geodesy

BARLOW, C. W. C., and BRYAN, G. H. "Elementary Mathematical Astronomy." 1893.
BRUNNOW, Francis. "Spherical Astronomy." 1865.
CHAUVENET, Wm. "Spherical and Practical Astronomy." 2 Vols. 1887.
HAYFORD, John F. "A Text-Book of Geodetic Astronomy." 1904.
NEWCOMB, Simon. "Compendium of Spherical Astronomy." 1906.
POINCARÉ, H. "Cours d' Astronomie Générale." 1904-5.
PRATT, John H. "On Attractions, Laplace's Functions, and the Figure of the Earth." 1868.

DIVISION VII.—Theoretical Astronomy, Celestial Mechanics

BAUSCHINGER, Julius. "Die Bahnbestimmung der Himmelskörper." 1906.
CARR, Nathan T. "The Sun: its constitution, its phenomena, its condition." 1883.
COFFIN, J. H. C. "Theoretical Navigation; being class lectures delivered at the U. S. Naval Academy, Annapolis, Maryland, 1854."
CROLL, James. "Stellar Evolution and its relation to Geological Time." 1889.
DREYER, J. L. E. "History of the Planetary Systems from Thales to Kepler." 1906.
HALE, George Ellery. "The Study of Stellar Evolution." 1908.
KIRKWOOD, Daniel. "Comets and Meteors." 1873.
"Meteoric Astronomy." 1867.
"Cometary Astronomy." 1861.
KEDZIE, J. H. "Solar Heat, Gravitation and Sun Spots." 1886.
KERIGAN, Thomas. "A Treatise on Eclipses and the Theory of Tides." 1844.
LOCKYER, Sir Norman. "The Meteoritic Hypothesis." 1890.
LYNN, Wm. Thynne. "Celestial Motions." 1894.
MOULTON, F. R. "An Introduction to Celestial Mechanics." 1902.
D'OPPOLZER, Théodore. "Traité de la Determination des Orbites des Comètes et des Planètes." Vol. i. 1886.
POINCARÉ, H. "Leçons de mécanique céleste professées à la Sorbonne." 1905.

SAINT-BLANCAT, D. "Action d'une Masse Intramercurielle sur la Longitude de la Lune." 1907.
SEE, T. J. J. "Evolution of the Stellar Systems." Vols. i., ii. 1896 and 1910.
SOUCHON, Abel. "Traité D'Astronomie Théorique." 1891.
STIRLING, William. "New Theories in Astronomy." 1906.
TAYLOR, F. B. "The Planetary System: a study of its structure and growth." 1903.
WILLIAMS, W. Mattieu. "Current Discussions in Science. (2 copies). 1882

DIVISION VIII.

Practical Astronomy, Instruments, Methods of Observation

BOWDITCH, Nathaniel. "American Practical Navigator." 1886.
CAMPBELL, W. W. "Elements of Practical Astronomy." 1904.
CHAMBERS, Geo. F., and SMYTH, Sir Wm. H. "A cycle of Celestial Objects, observed, reduced and discussed by Admiral Sir Wm. Henry Smyth." 2nd edition. 1881.
CHEYNE, C. H. H. "On the Planetary Theory." 1878.
CLERKE, Agnes M. "The System of the Stars." 1st and 2nd editions. 1890 and 1905.
DENNING, W. F. "Telescopic Work on Starlight Evenings." 1891.
DICK, Thomas. "The Practical Astronomer." 2 copies. 1888. "The Telescope and Microscope."
DOOLITTLE, C. L. "Practical Astronomy as applied to Geodesy and Navigation" 1903.
GORE, J. Ellard. "Astronomical Lessons." 1890
JACOBY, Harold. "Practical Talks by an Astronomer." 1902.
KELVIN, Lord, (Sir Wm. Thomson). "Navigation." (A lecture at Glasgow, 1875). 1876.
LOCKYER, J. Norman. "Stargazing, past and present." 1878.
LOOMIS, Elias. "Practical Astronomy." 1860.
MAIN, Rev. Robert. "Practical and Spherical Astronomy." 1863.
MASON, E. P. "Introduction to Practical Astronomy." (Designed as supplement to Olmsted's Astronomy). 1843.
MAUNDER, E. W. "Astronomy Without a Telescope." 1903.
NARRIEN, John. "Practical Astronomy and Geodesy." 1845.
NOBLE, Wm. "Hours with a Three-Inch Telescope." 1887.
SERVISS, Garrett P. "Astronomy with an Opera-Glass." 3 copies. 4th edition 1890 and 1892; 8th edition 1901. "Pleasures of the Telescope." 1901.
SMYTH, W. H. "A Cycle of Celestial Objects." (See Chambers, Geo. F.),
SOUCHON, Abel. "Traité D'Astronomie Pratique." 1883.

TODD, David P. "Stars and Telescopes." 1900.
TURNBULL, M. "Description of a New Celestial and Terrestial Globe." 1892.
WARNER and SWASEY. "A Few Astronomical Instruments." 1900.
WARREN, Henry White. "Recreations in Astronomy, with directions for practical experiments and telescope work." 1879.
WEBB, Rev. Thos. W. "Celestial Objects for Common Telescopes." 2 vols. 1893-4.
"Celestial Objects, etc." 4th edition. 1881.
"Manuscript Note Book." Presented to Library by Mr. G. Parry Jenkins in 1910).
WILLIAMS, A. Stanley. "Zenographical Fragments." Vols. i. and ii. 1889 and 1900.

DIVISION X.—Observations, Descriptive Astronomy, Astrophysics

ALLEN, Richard Hinckley. Star-Names and their Meanings." 1899.
ARRHENIUS, Svante. "The Life of the Universe," as conceived by man from the earliest ages to the present time. Vols i. and ii. 1909.
"Worlds in the Making." Translated by Dr. H. Borns. 1908.
ASHE, Commander. "Proceedings of the Canadian Eclipse Party 1869."
BALL, Sir Robt. "The Story of the Sun." 1901.
"In the High Heavens." 1894.
BALY, E. C. C. "Spectroscopy." 1905.
BOQUET, F. "Les Observations Meridiennes." (Théorie et Pratique). Vols. i. and ii. 1909.
BRENNER, Leo. "Mars-Beobachtungen 1896-7." Berlin, 1898.
CHAMBERS, Geo. F. "The Story of the Comets." Simply told for general readers. 1909.
"The Story of Eclipses." 1899.
"The Story of the Stars." 1901.
"The Story of the Solar System." 1901.
CLERKE, Agnes M. "Problems in Astrophysics." 1903.
"Modern Cosmogonies." 1905.
CLERKE, Ellen M. "Jupiter and his Systems." 2 copies. 1892.
DURKIN, Edwin. "The Midnight Sky, Familiar Notes on the Stars and Planets." 1870.
ELGER, Thomas Gwyn. "The Moon." A full description and Maps of its principal physical features. 1895.
FAUTH, Philip. "The Moon in Modern Astronomy." Introduction by J. E. Gore.

FLAMMARION, Camille. "La Planète Mars." Vols. i. and ii., 1892, and 1909.
"Wonders of the Heavens." Translated by Mrs. Norman Lockyer. 2 editions. 1871 and 1880.
"Excursions dans le Ciel."
FORBES, George. "The Transit of Venus." 1874.
GALL, Rev. James. "Easy Guide to the Constellations, with. . . . Atlas of the Stars." 1900.
GARBASSO, A. "Vorlesungen über Theoretische Spectroskopie." 1906.
GORE, J. Ellard. "The Scenery of the Heavens." 2nd edition. 1892.
"Southern Stellar Objects for Small Telescopes." 1877.
"Star Groups." 1891.
HEATH, Thomas. "The Twentieth Century Atlas of Popular Astronomy." Comprising in twenty-two plates a complete series of illustrations of the heavenly bodies. 1903.
HILL, Royal. "Stars and Constellations." A new method by which all the more conspicuous stars, constellations, and other objects of interest in the heavens, that are visible to the naked eye, can be easily and certainly identified. 3rd edition. 1894.
HONORÉ, Carlos. "El Sol." 1897.
HUGGINS, Sir Wm. and Lady. "Atlas of Representative Stellar Spectra." 1899.
"The Scientific Papers of Sir Wm. Huggins." (Being Vol. ii. of "Atlas of Representative Stellar Spectra.") 1909.
"Spectrum Analysis: as applied to the heavenly bodies." 1866.
IRVING, Edward. "How to Know the Starry Heavens." 1904.
JAMIESON, Alex. "Celestial Atlas." 1822.
KIRCHHOFF, G. "Researches on the Solar Spectrum and the Spectra of the Chemical Elements." Translated by H. E. Roscoe. 1862.
KOBOLD, Hermann. "Der Bau des Fixsternsystems." 1906.
KRIEGER, J. N. "Mond-Atlas:" Entworfen nach den Beobachtungen an der Pia-Sternwarte in Trieste. Vol. i. 1898.
LOCKYER, Sir Norman. "Recent and Coming Eclipses: being Notes on the Total Solar Eclipses of 1893-6 and 1898." 1897.
LONG. "Astronomical Plates."
LOWELL, Percival. "Mars." 1895.
"Mars and Its Canals." 1906.
"Mars as the Abode of Life." 1908.
"The Evolution of Worlds." 1909.
LYNN, Wm. Thynne. "Remarkable Comets." 1901.

MARTIN, Martha Evans. "The Friendly Stars." (With diagrams). 1907.

MAUNDER, E. W. "The Indian Eclipse, January 22, 1898." 1899.

"The Total Solar Eclipse of May, 1900." 1901.

MEE, Arthur. "Observational Astronomy." (2 copies). 1st edition, 1893; 2nd edition, 1897.

MITTON, G. E. "The Children's Book of Stars." 1908.

MORSE, Edward S. "Mars and Its Mystery." 1906.

MOYE, Professor. "À la Poursuite d'une ombre, l'eclipse de soleil du 30 août, 1905."

NASMYTH, Jas., and CARPENTER, Jas. "The Moon: considered as a Planet, a World, and a Satellite." 1874.

NEISON, Edmund. "The Moon, and the Condition and Configuration of its Surface." 1876.

NICHOL, J. P. "The Architecture of the Heavens." (2 copies). 5th and 9th editions. 1845 and 1851.

PICKERING, Wm. H. "Lunar and Hawaiian Physical Features Compared." 1906.

"The Moon." 1903.

PROCTOR, Mary. "Giant Sun and His Family." 1906.

"Stories of Starland." 1906.

PROCTOR, Richard A. "Saturn and Its System." (2nd edition). 1882.

"The Expanse of Heaven." 1905.

ROBERTS, Isaac. "Photographs of Stars." (Selections of photographs of stars, star-clusters and nebulæ, together with information about the instruments and methods employed in celestial photography). Vols. i. and ii. (2 copies).

ROSCOE, Henry E. "Spectrum Analysis." 3rd edition. 1873.

ROSCOE, Henry E., and SCHUSTER, Arthur. "Spectrum Analysis." 4th edition. 1885.

SALET, P. "Spectroscopie Astronomique." 1909.

SCHEINER, J. "Astronomical Spectroscopy." (A translation of "Die Spectralanalyse der Gestirne," revised and enlarged by E. B. Frost). 1898.

SCHELLEN, H. "Spectrum Analysis." (Translated by Jane and Caroline Lassell and edited by Wm. Huggins). 1872.

SHALER, N. S. "Comparison of the Features of the Earth and the Moon." 1903.

STEELE, Joel D. "New Descriptive Astronomy." 1884.

SWIFT, Lewis. "Simple Lessons in Astronomy." 1890.

TODD, Mabel Loomis. "Total Eclipses of the Sun." 2 copies. 1894 and 1900.

VOGEL, H. C. "Uber den neuen Stern im Fuhrmann." 1893.

WALLACE, Alfred Russel. "Is Mars Habitable?" 1907.
WATTS, W. M. "An Introduction to the Study of Spectrum Analysis." 1904.
WEBB, Rev. Thos. W.. "The Sun: a familiar description of his phenomenon." 1885.
WILLARD, E. "Astronography, or Astronomical Geography: with the use of the Globes." 1856.

DIVISION XI.—Ancient Astronomy

DERHAM, W. "Astro-Theology." (2 copies). 3rd and 9th editions. N. D. and 1750.
GALILEO. "Opera." Tome i. and ii.
LOWTHROP, John. "Philosophical Transactions abridged." Vols. i. and ii. 1705.
WELLS, Edward. "The Young Gentleman's Astronomy." (2nd edition). 1718.
WITTIE, Robert. "Ouranoscopia: or a Survey of the Heavens." 1681.

DIVISION XIII.—Works on Physics

ABBE, Cleveland. "The Mechanics of the Earth's Atmosphere." 1910.
AIRY, Sir George Biddell. "On the Undulatory Theory of Optics." London, 1866.
ARCHIBALD, Douglas. "The Story of the Earth's Atmosphere." 1901.
BESANT, W. H. "Hydrostatics and Hydrodynamics." 1859.
BLACK, F. A. "Terrestial Magnetism and Its Causes." 1905.
BLONDLOT, R. "N" rays: a collection of papers communicated to the Academy of Science, with additional notes and instructions for the construction of phosphorescent screens. Translated by J. Garcen. 1905.
CAVALLO, Tiberius. "A Treatise on the Nature and Properties of Air." 1781.
CHAMBERS, Geo. F. "The Story of the Weather." 1900.
CLAUSIUS, R. "The Mechanical Theory of Heat." Translated by W. R. Browne. 1879.
CLAYDEN, Arthur W. "Cloud Studies." 1905.
CUNYNGHAME, H. H. "Time and Clocks:" a description of Ancient and Modern methods of measuring time. 1906.
DARWIN, Geo. Howard. "The Tides." 1898.
DESCHANEL, A. Privat. "Natural Philosophy." 4th edition. Translated by J. D. Everett. 1878.
DOLBEAR, A. E. "Matter, Ether and Motion." English edition edited by Prof. Lodge. 1903.
DUNCAN, R. K. "The New Knowledge." 1905.

DUTTON, Clarence Edward. "Earthquakes: in the light of the new seismology." 1905.

FESSENDEN, Reginald Aubrey. "A determination of the nature of the electric, and magnetic qualities, and of the density and elasticity of Ether." 1900.

FOURNIER, d'Albe E. E. "Electron Theory:" a popular introduction to the new theory of electricity and magnetism. 1906.

GIBSON, Chas. R. "Scientific Ideas of To-Day Popularly Explained." 2nd edition. 1909.

GRIFFIN, Wm. N. "A Treatise on Optics." 2nd edition. 1842.

HAANEL, Eugene. "Galvanometric method for determining the Earth's magnetism, and its oscillations." 1873.

HAGENBACH, August, and KONEN, Heinrich. "Atlas of Emission Spectra." (Authorized Eng. edition by Arthur S. King. 1905.

HARRINGTOM, Mark W. "About the Weather." 1901.

HIGGS, Paget. "The Electric Light in its Practical Application." 1879.

HOGG, Jabez. "Elements of Experimental and Natural Philosophy." 1861.

KELVIN, Lord, (Sir Wm. Thomson). "Baltimore Lectures on Molecular Dynamics and the Wave Theory of Light." 1904.

KELVIN, Lord, (Sir Wm. Thomson) and P. G. TAIT. (See Thomson). "Natural Philosophy." Vol. i. 1867.

LAMB, Horace. "The Motion of Fluids." 1879.

LARMOR, Joseph. "Æther and Matter." 1900.

LEFROY, Sir J. H. "Diary of a Magnetic Survey of . . .Canada . . . 1842-44." 1883.

LODGE, Sir Oliver. "Life and Matter: a criticism of Professor Hæckel's 'Riddle of the Universe.'" 1905.
"The Ether of Space." 1909.

LOUDON, James and CHANT, C. A. "Elementary Mechanics." 1892.

MAXWELL, James Clerk. "Electricity and Magnetism." Vols. i. and ii. 1873.

MCLENNAN, Evan. "Cosmical Evolution." 1890.

MENDELÉEFF, D. "A Chemical Conception of the Æther." 1904.

MICHELSON, A. A. "Light-Waves and Their Uses." (Decennial Publications of the University of Chicago: Second Series. Vol. iii). 1903.

MILLER, W. H. "Elements of Hydrostatics." (4th edition).

MUNRO, John. "The Story of Electricity." 1899.

NEWTON, Sir Isaac. "Principia." (Translated by Andrew Motte). 1846.

PARKINSON, S. "Mechanics, Treatise on." 1863.
POINCARÉ, H. "Science and Hypothesis." (Translation by G. B. Halsted). 1905.
"The Value of Science." (Authorized trans. and introduction by Halsted). 1907.
PRESTON, Thomas. "The Theory of Light." 2nd edition. 1895.
REYNOLDS, Osborne. "The Sub-Mechanics of the Universe." (Papers on Mechanical and Physical Subjects: Vol. iii.). 1903.
ROUTH, Edw. John. "Dynamics of a System of Rigid Bodies." 3 copies. 1st, 2nd and 3rd editions. 1860-8 and 1877.
RUTHERFORD, E. "Radio-Activity." 1904.
SCHUSTER, A. "Theory of Optics." 1904.
SMITHSONIAN INSTITUTION. "Short Memoirs on Meteorological Subjects." 1877.
STEVENSON, Alan. "Report. . . . on illuminating Light-houses by means of Lenses." 1835.
STEWART, Balfour. "The Conservation of Energy." 1873.
STOKES, Geo. G. "Light as a means of Investigation." 1875.
TAIT, Peter Guthrie, and STEELE, Wm. J. "Dynamics of a Particle." 1865.
THOMSON, J. J. "Electricity and Matter." 1904.
THOMSON, Sir William. (See Lord Kelvin).
TODHUNTER, I. "History of the Mathematical Theories of Attraction and the Figure of the Earth." 2 Vols. 1873.
"On Analytical Statics." 1858.
WALKER, Edward. "Terrestrial and Cosmical Magnetism." 1866.
WHEELER, W. H. "A Practical Manual of Tides and Waves." 1906.
WHETHAM, W. C. D. "The Recent Development of Physical Science." 1904.
WILKINSON, C. H. "Elements of Galvanism." 2 Vols. 1806.
WOOD, Robert W. "Physical Optics." 1905.
WOOD, De Volson. "The Luminiferous Æther." 1886.
WORTHINGTON, A. M. "The Splash of a Drop." 1895.

DIVISION XIV.—Works on Mathematics

ALDIS, W. Steadman. "Elementary Treatise on Solid Geometry." 2nd edition. 1873.
BEASLEY, R. D. "Elementary Treatise on Plane Trigonometry." 1858.
BECKER, Geo. F., and VAN OSTRAND, C. E., "Hyperbolic Functions." (Smithsonian Mathematical Tables). 1909.

BOOLE, George. "On the Calculus of Finite Differences." 1860.
"Differential Equations." 2 Vols. 1865.
BRIGGS, Wm., and BRYAN, G. H. "The Tutorial Dynamics." 2nd edition. 1906.
"The Tutorial Statics." 3rd edition. 1905.
DE MORGAN, Augustus. "Elements of Mathematics." 1854.
"On the Study and Difficulties of Mathematics." 1898.
"Probability." [Library of Useful Knowledge].
DREW, Rev. W. H. "Conic Sections." 1862.
EUCLID. "Elements:" with the notes, etc., of Dr. Simson.
FERRERS, N. M. "Treatise on Trilinear Co-Ordinates." 1861.
FILIPOWSKI, Herschell E. "Table of Anti-Logarithms." 1861.
FROST, Rev. Percival, and WOLSTENHOLME Rev. Joseph. "Solid Geometry." 1863.
HALL, Rev. T. G. "On the Differential and Integral Calculus, and the Calculus of Variations." 4th edition. 1846.
HALSTED, George Bruce. "Rational Geometry." 1st edition. 1904.
LOOMS, Elias. "Analytical Geometry and the Differential and Integral Calculus." 10th edition. 1860.
MANNING, Henry. "The Fourth Dimension." 1910.
MORRISON, J. "Plane Trigonometry." 1880.
VAN OSTRAND, C. E., and BECKER, Geo. F. (See Becker).
POTTS. "Elements of Euclid."
SALMON, George. "Analytic Geometry of Three Dimensions." 1865.
"Conic Sections." 1863.
TODHUNTER, I. "Conic Sections." 1862.
"Differential Calculus." 1860.
"Researches in the Calculus of Variations." 1871.
"History of the Mathematical Theory of Probability." 1865.
"On the Integral Calculus." 1862.
"Analytical Geometry of Three Dimensions." 1858.
VOSE, Geo. L. "Algebraic Problems." 1875.
WOLSTENHOLME, Joseph. "Mathematical Problems on Subjects in the Cambridge Course." 1867.
WRIGLEY, Rev. Alfred. "Examples and Problems in Pure and Mixed Mathematics." 6th edition. 1862.

DIVISION XV.—Monographs (Bound)

The *Volumes* referred to in this Division are the Bound Volumes of Monographs on the Library Shelves.

ABBE, Cleveland. "Historical Notes on the System of Weather Telegraphy." Vol. xviii.
"Physics of the Globe." Vol. xviii.

ABBOT, C. G. "Some Recent Astronomical Events." (From the Smithsonian Report 1901).

ALEXANDER, S. "Certain Harmonies of the Solar System." 1875. Vol. iii., No. 5.

ASHE, Commander E. D. "On Solar Spots." 1866. Vol. xvi.

BACKHOUSE, T. W. "Structure of the Sidereal Universe." 1891. Vol. vii.

BALL, Sir Robt. "Observations made with the South Refractor." 1884. Vol. iv., No. 3.

"Notes on Mars." 1901. Vol. xiv.

"Twelfth Memoir on the Theory of Screws." 1898. Vol. xix.

BARKER, Geo. F. "Electrical Progress Since 1743." 1893. Vol. xvii.

BARNARD, E. E. "Diameter of the Asteroid Juno, with remark on other Asteroids." 1900. Vol. xvi.

"Probable Motion of Small Stars in the 'Dumb-Bell' Nebula." 1902. Vol. xvi.

"On the Dimensions of the Planets and Satellites, and on the Surface Features of these Bodies." 1902. Vol. xv.

"Total Eclipse of the Sun in Sumatra." Vol. xvi.

"Micrometer Measures of the Fifth Satellite of Jupiter." 1893. Vol. vi., No. 2.

"Recent Observations of Nova Aurigæ and further Observations in 1901.

"Micrometrical and Visual Observations of Nova Cygni, 1876." 1902. Vol. xvi.

BRENNER, Leo. "Observations de Mars et Saturne." 1897. Vol. xiv.

"Jupiter-Beobachtungen an der Manora-Sternwarte 1895-6." 1897. Vol. xv.

"Thätigkeit der Manora-Sternwarte im Jahre 1896-9." Vol. xv.

BROWN, Allan J. "Annular Eclipse of the Sun, March 15-16, 1885." 1885. Vol. v., No. 4.

BRÜNNOW, Francis. Further Researches on the Parallax of Stars." 1873. Vol. iv., No. 1.

BURNHAM, S. W. "Double Star Observations at Lick Observatory, 1889-90." Vol. vii.

"Double Star Observations at Chicago, 1877-8." Vol. vii., (also in "Memoirs Royal Astronomical Society Vol. xliv.)

"Double Star Discoveries."

"New Double Stars."

"Invisible Double Stars."

"Double Star Measures of Bedford Catalogue."

"Seventh Catalogue of New Double Stars."

BURNHAM S. W.—(Continued).
"Duplicity of Principal star of ν Scorpii."
"Orbit of κ Pegasi (β 989)."
"Proper Motion of *H.* 1968."
"Quadruple Stars."
"Companions of Aldebaran."
"Bright Wire Illumination for Position Micrometers."
"Sirius."
"Trapezium of Orion." All in Vol. viii.
"Sixth Catalogue of 90 New Double Stars." 1875. Vol. xix.

CARPENTER, Wm. "One Hundred Proofs that the Earth is not a Globe." Vol. viii.

CARPMAEL, Chas. "Reduction of the Barometer to Sea Level, with Tables." 1878. Vol. xviii.

CHESSIN, Alex. S. "On the Motion of Gyroscopes." 1902. Vol. xvii.
"On the True Potential of the Force of Gravity." 1902. Vol. xvii.

CLERKE, Agnes M. "Stellar Numbers and Distances."
"The Sun's Motion in Space."
"A Southern Observatory." 1893. Vol. xvi.
"Nova Aurigæ." Vol. x.

COFFIN, J. H. C. "Psychrometrical Tables for Determining the Force of Aqueous Vapors and the Humidity of the Atmosphere." Vol. x.

DAWSON, Alfred. "A Theory of Gravity and of the Solar Process." 1884. Vol. xvi.

DECHEVRENS, M. "Vertical Currents in Cyclones." Vol. xviii.

DENNING, W. F. "Catalogue of Radiant Points of Meteoric Showers, and of Fireballs and Shooting Stars." 1899. Vol. xix.
"Radiant Points (918) of Shooting Stars." Vol. viii.
"Bright Meteors Observed at Bristol, 1887-9." Vol. viii.

DOWNING, A. M. W. "Precession Tables . . . reduced to the Epoch 1910·0." 1899. Vol. xix.

DRAPER, Henry. "On the Construction of a Silvered Glass Telescope . . ." 1864. Vol. iii., No. 2.

DREYER, J. L. E. "Mean Places of 321 Red Stars." 1882. Vol. iv., No. 2.

EDDY, H. T. "Liquefaction, Vaporization, and the Kinetic Theory of Solids and Liquids." 1883. Vol. xvii.

ESPIN, T. E. "A Possible Factor in Volcanic Eruptions." 1902. Vol. xviii.
"Spectroscopic Observations of Nova Aurigæ." Vol. x.

FARGIS, G. A. "The Photochronograph and its Application to Star Transits." 1891. Vol. v., No. 6.
FAULHABER, C. "Construction of Large Telescope Lenses." (Reprint from Smithsonian Report, 1904).
FAUTH, Philip. "Beobachtungen der Planeten Jupiter und Mars aus den Oppositionen von 1896-7." 1898. Vol. xv.
FLAMMARION, Camille. "La Planète Mars." Vol. xiv.
"Rapport sur les Travaux de la Station de Climatologie Agricole de Juvisy, 1900." 1901. Vol. xiii.
FLEMING, Sir Sandford. "Time Reckoning for the 20th Century." Vol. viii.
"Unit Measure of Time." Vol. viii.
"Universal or Cosmic Time." Vol. viii.
GILBERT, G. K. "The Moon's Face." Vol. x.
GISBORNE, F. N. "Telephone." 1888. Vol. xvii.
GORE, J. Ellard. "On the Variable Star *U* (Nova) Orionis."
"Orbit of 99 Herculis."
"Orbit of the Binary Star ι Leonis."
"Orbit of the Binary Star 35 Comæ Berenices = Σ 1687."
"Orbit of γ Coronæ Australis." (All in Vol. viii.)
"Orbit of γ Centauri." Vol. viii.
"Orbit of O Σ 269." Vol. viii.
"Observations of Nova Persei." 1901. Vol. xvi.
"Orbit of Σ 1785 and of Binary Star β 416. 1893. Vol. xvi.
"On the Orbit of O Σ 82." 1902. Vol. xvi.
"Changes in the Stellar Heavens." 1901. Vol. xvi.
GUILLAUME, C. E. "The Extreme Infra-Red Radiations." 1900. Vol. xvi.
GUILLAUME, J. Observations Physiques de Mars." 1890. Vol. xiv.
HALL, Asaph. "Saturn and Its Rings, 1875-89." Vol. vii.
"Observations of Double Stars." 1881. Vol. v., No. 2.
"Parallax of α Lyræ and 61 Cygni." 1882. Vol. v., No. 3.
"Observations for Stellar Parallax." 1886. Vol. v., No. 6.
HARKNESS, Wm. "On the Magnitude of the Solar System." 1896. Vol. xvi.
"On the Flexure of MeridianI nstruments." 1886. Vol. v., No. 5.
HAZEN, Henry A. "Thermometer Exposure." 1884. Vol. xviii.
"Air Temperature and Humidity." 1885. Vol. xviii.
"Anemometer Comparisons." 1889. Vol. xviii.
"The Sun Glows." 1884. Vol. xvi.
HENDON HOUSE Observatory Publications Vol. i. "The Structure of the Sidereal Universe." (By T. W. Backhouse). 1891. Vol. vii. (See also Div. III.)

HILL, G. W. "On the part of the motion of the Lunar Perigee which is a function of the Mean Motions of the Sun and Moon." 1877. Vol. xix.

HOLDEN, E. S. "The Multiple Star, Σ 748." Vol. vii. No. 1.
"Beginnings of American Astronomy." 1898. Vol. xvi.

HUGGINS, Sir Wm. "Celestial Spectroscopy." 1893. Vol. xvi.

HUGO, Cte. Leopold. "Astronomie Géometrique." 1876. Vol. xiii.

HUNT, T. Sterry. "Celestial Chemistry from the Time of Newton." 1882. Vol. xvi.

JANSSEN, M. J. "Photographic Photometry." 1896. Vol. xvi.

JOHNSON, Arnold B. "Sound Signals." 1884. Vol. xviii.

KANE, Eliska K. "Astronomical Observations in the Arctic Seas." 1860. Vol. iii., No. 1.

KEELER, J. E. "On the Spectra of the Orion Nebula and Star." Vol. ix.
"Spectroscopic Observations of Nebulæ." 1894. Vol. vi., No. 9.
"Spectroscopes for Astronomical Purposes."
"The Star Spectroscope of Lick Observatory."
"The Modern Spectroscope of . . . Allegheny Observatory." (All in Vol. ix.).
"Physical Observations of Mars in 1892." Vol. vii.

KELVIN, Lord, (Sir Wm. Thomson). "Steps towards a Kinetic Theory of Matter." 1884. Vol. xvii.

LANGLEY, S. P. "Sur les Spectres Invisibles. 1886. Vol. xvi.
"The Astrophysical Observatory." 1897. Vol. xix.
"Temperature of the Surface of the Moon." 1884. Vol. xix.
"Wave-Lengths in the Invisible Prismatic Spectrum." 1883. Vol. xix.
"Solar and Lunar Spectrum." 1886. Vol. xix.
"Preliminary Account of the Solar Eclipse of May 28, 1900. 1901. Vol. xvi.
"Invisible Heat Spectra, and the Recognition of hitherto unmeasured Wave-Lengths." Vol. xvi.
"Expérimentelle Bestimmung der Wellenlängen im unsichtbaren prismatischen Spectrum." Vol. xiii.

LEHARDELAY, Chas. "Résultats d'observations de la Planète Saturne faites 1868 à 1874." Vol. xiv.

LINDSAY, Thos. "Historical Sketch of Greenwich Nautical Almanac." 1899. Vol. xvi.

LOCKYER, Sir Norman. "Chemistry of the Stars." 1900. Vol. xvi.

LOOMIS, Elias. "Aurora Borealis or Polar Light: its phenomena and laws." Vol. xiv.

LOUDON, James. "Geometrical Methods chiefly in the theory of thick lenses." 1885. Vol. xvii.

LOWELL, Percival. "New Observations of Mercury." 1897. Vol. xv.

MEECH, L. W. "On the relative intensity of the Heat and Light of the Sun upon different Latitudes of the Earth." 1855. Vol. iii., No. 4.

MERRY, Alfred Senior. "Interstellar Æther." 1891. Vol. xviii.

MORRISON, J. "Apparent Orbit of a Satellite of a Superior Planet." Vol. x.

"Orbit of Great Comet (*b*) 1882." Vol. x.

"Orbit of Barnard's Comet 1884." Vol. x.

"Orbits of Comets Fabry, and Barnard-Hartwig." Vol. x.

"Transits of Venus for 1874 and 1882; and of Mercury for 1878." 1873. Vol. xiv.

"Eccentric Anomaly of Planets." Vol. x.

"Ephemerides of Satellites of Mars during oppositions of 1888 and 1890. Vol. x.

NEWCOMB, Simon. "Aspects of American Astronomy." 1898. Vol. xvi.

"On the General Integrals of Planetary Motion." 1874. Vol. iii., No. 3.

"On the Right Ascensions of the Equatorial Fundamental Stars." 1872. Vol. v., No. 1.

"An Investigation of the Orbit of Neptune." 1865. Vol. i., No. 1.

NICHOLS, E. F. "Transmission Spectra of certain substances in the Infra-Red." 1893. Vol. xvi.

NIESTEN, L. "Rotation de la Planète Venus." 1891. Vol. xiv.

"Note Relative aux Variations de Latitude." 1892. Vol. xiii.

NIPHER, Francis E. "Physics during the last Century." 1901. Vol. xvii.

PARKHURST, H. M. "Notes on Variable Stars." 1899. Vol. xix.

PASSALSKY, P. "Anomalies Magnétiques dans la région des mines de Krivoi-Rog. 1901. Vol. xv.

PAULSEN, Adam. "L'Aurore Polaire." 1900. Vol. xiv.

"Resultat de Mésures . . de parties correspondants des Spectres de l'Aurore Polaire . . ." 1901. Vol. xiv.

PEAL, E. S. "A Possible cause for Lunar Libration." 1891. Vol. xiv.

"Theory of Lunar Surfacing by Glaciation." Vol. x.

PERRY, S. J. "Phenomena Observed upon the Solar Surface, 1881-84." Vol. xvi.

DE PEYSTER, J. Watts, and ALLABEN, Frank. "Do Ocean Currents demonstrate a Diurnal Rotation of the Earth." 1900. Vol. xviii.

PICKERING, W. H. "Schiaparelli's latest views regarding Mars." Vol. xiv.

"Orations on the Aims of an Astronomer." 1906. Vol. xv. No. 57.

PORTER, Jermain G. "Historical Sketch of Cincinnati Observatory, 1843-93." Vol. x.

RAMBAUT, A. A. "Mean places of 1012 Southern Stars." 1887. Vol. iv., No. 4.

RANYARD, A. C. "The Great Lunar Crater Tycho." 1894. Vol. xiv.

ROGERS, Jos. A. "The Correction of Sextants for Errors of eccentricity and graduation." 1890. Vol. xviii.

SCHÆBERLE, J. M. "Aberration in the Focal Plane of a Parabolic Reflector." 1898. Vol. xix.

"Fundamental Optical Defect in Images formed by a Parabolic Reflector." 1897. Vol. xix.

"Formulas for the Cassegrain (and Gregory) Telescopes." 1896. Vol. xix.

SCHIAPARELLI G. V. "Sur la Rotation et sur la Constitution physique de Mercure." 1889. Vol. xiv.

"Il Pianeta Marte." 1893. Vol. xv.

SCHOTT, Chas. A. "Tables and Results of the Precipitation in Rain and Snow in the U. S." 1881. Vol. ii.

SEE, T. J. J. "Preliminary Investigation of the Diameter of Mars" 1901. Vol. xv.

"Equatorial Diameter of Saturn and Dimensions of his System of Rings." 1901. Vol. xv.

"Satellites of Saturn and Uranus." 1902. Vol. xv.

"Probable Diameters, Masses and Densities of those Satellites which have measurable discs." Vol. xvi.

"Discoveries and Measures of Double and Multiple Stars in the Southern Hemisphere." 1898. Vol. xix.

SIDGREAVES, Walter. "On the Connection between Solar Spots and Earth-Magnetic Storms." 1900. Vol. xix.

STEVENS, Rev. A. G. "Repulsion of Solid Bodies referable to Radiation." 1875. Vol. xvii.

STOCKWELL, John N. "Secular Variations of the Elements of the Orbits of the Eight Principal Planets." 1870. Vol. i., No. 2.

STROOBANT, Paul. "Observations de Saturne en 1890." Vol. xiv.

TERBY, F. "Visualité d'Oberon et de Titania."
"Note sur l'Aurore Boréale du 2 October, 1882."
"Note sur l'Aurore Boréale du 17 November, 1882."
"Note sur l'Aurore Boréale du 30 Mars, 1894."
"Periodicité mensuelle des Aurores Boréales."
"Decouverte de la rotation de Mercure par M. Schiaparelli."
"Sur la Structure des Bandes Equatoriales de Jupiter: Notes 1, 2, 3 and 4."
"Études sur l'aspect physique de Jupiter." 1887.
"Phénomènes des Satellites de Jupiter."
"Sur une éclipse du Satellite Japet dans l'ombre . . . de Saturne.
"Sur l'aspect de Titan en passage devant Saturne." 1892.
"Sur un nouveau passage de Titan et de son ombre, 12 Avril, 1892."
"Observations de M. Schiaparelli sur Mars." 1880.
"Taches de la Planète Mars"
"Études sur . . . Mars." Notices 9, 10, 11, 12."
"Gemination des Canaux de Mars."
"Aspect de la Planète Mars pendant l'opposition de 1879 . . . etc."
"Les premières observations de Mars et de Saturne faites à Lick."
"Sur une Observation de Saturne faites à Louvain." 1887.
"Phénomènes Observés sur Saturne."
"Considerations sur le mouvement de rotation de Venus." Art. 1, 2, 3. 4.
"Recherches sur la période lunaire des Aurores Boréales."
"Un Dernier mot en réponse à M. Flammarion." (All in Vol. xiv.
"Areographie, ou Observations de Mars."
"Areographische Fragmente (Mars)." 1873.
"Observations Physiques de Mars." 1889.
"Études sur la Planète Jupiter." 3 parts. (All in Vol. xv.)
"Aspects de la Grand Comète de 1882." (Cruls.) 3 parts. 1882-3.
"Notes sur la Comète de 1812." (Pons-Brooks). 1884.
"Sur les phénomènes crepusculaires des mois de Novembre et Décembre, 1883."
"Sur des Halos remarquables." 1892.
"Observations des 'Etoiles Filantes Periodiques . . . 1882-3."
"Note sur la pluie d 'Etoiles Filantes du 27 Novembre, 1885."
"Observations des Comètes *b* et *c* de 1881." (All in Vol. xiii.)
"Sur la Périodicité mensuelle des phénomènes Magnétiques." 1888. Vol. xviii.

TINSLEY, G. W. "The Vaster Forces in Meteorology and Astronomy." Vol. x.
TISCHNER, August. "L'Astronomie et les Astronomes." 1893. Vol. xiii.
"Les Astronomes." 1893. Vol. xiii.
"Le Mouvement de la lumière." 1892. Vol. xiii.
"Le pouvior grossissant de l'Atmosphère." 1892. Vol. xiii.
"Le Mouvement Universal." 1893. Vol. xiii.
"Le Système solaire se mouvant." 1894. Vol. xiii.
TURNER, H. H. "On New Forms of Levels." 1891. Vol. xvii.
"Annual Variation in the R.-D. Discordance." 1892. Vol. xiii.
"Observations for Coincidence of Collimators." 1892. Vol. xiii.
UPTON, Winslow. "Use of the Spectroscope in Meteorological Observations." 1883. Vol. xviii.
VEEDER, M. A. "Thunderstorms." 1893. Vol. xviii.
"Solar Electro-Magnetic Induction." Vol. ix.
"Solar Electrical energy not transmitted by Radiation." Vol. ix.
"Thunderstorms." Vol. ix.
"Zodiacal Light." Vol. ix.
VERY, Frank W. "Hail Storms." (2 copies, in Vols. x. and xi.)
VOGEL, E. "Atomic Weights under Atmospheric Pressure not Identical with Specific Gravities." Vol. ix.
VOGEL, H. C., and WILSING, J. "Untersuchungen über die Spectra von 528 Sternen." 1899. Vol. xix.
WHYMPER, Edw. "How to use an Aneroid Barometer." 1891. Vol. xvii.
YOUNG C. A. "Variable Stars." 1894. Vol. xvi.

DIVISION XVI.—Other Works Unclassified.

BAILLAIRGE, G. F. "Arctic Voyages . . . Canada." Memoranda.
BRITISH ASSOCIATION for the Advancement of Science. "Handbook of Canada." 1897.
CASSIDY, Wm. J. "Age of Creation." 1887.
DWIGHT, M. A. "Grecian and Roman Mythology." 1849.
FAIRCHILD, G. M., Jr., Editor. "Canadian Leaves." (History, Art, Science, etc.). 1888.
FOWNES, George. "Elementary Chemistry: theoretical and practical." 9th edition. 1863.
GERARD, John. "The Old Riddle and the Newest Answer." 1904.

HALIBURTON, R. G. "How a Pigmy Race was found in North Africa and Spain, and papers on other subjects." 1898.

HUMBOLDT LIBRARY: 1 Vol. containing:—

"The Forms of Water."— *Tyndall.*
"Six Lectures on Light."— *Tyndall.*
"The Conservation of Energy."— *Stewart.*
"Evidence as to Man's Place in Nature."— *Huxley.*
"Lectures on Evolution."— *Huxley.*
"The Romance of Astronomy."— *Miller.*
"Lessons in Electricity."— *Tyndall.*
"Force and Energy."— *Allen.*
"A Half Century of Science."— *Huxley and Allen.*

LOW, A. P. "The Cruise of the Neptune, 1903-4."

MILLER, Hugh. "The Old Red Sandstone." 1852.

MILLER, Wm. Allen. "Elements of Chemistry." 1868. 2 Vols. (Part 2, Inorganic; Part 3, Organic).

MUIR, M. M. P. "The Story of the Chemical Elements." 1898.
"The Story of the Wanderings of Atoms." 1899.

MUNDY, Lt.-Col. G. C. "Our Antipodes: Rambles in the Australasian Colonies." 1852. Vols. i. and iii.

RICHARDS, Joseph W. "Aluminium: its history, occurrence . . . etc." 1887.

SMEE, A. H. "Suggestions as to lines for future Research." 1881.

TILDEN, Wm. A. "Introduction to Chemical Philosophy." 1884.

WELLER, Stuart. "The Trilobita." (The Paleontology of the Niagaran Limestone in the Chicago Area). 1907.

WOODRUFF, Frank Morley. "The Birds of the Chicago Area."

WURTZ, Ad. "A History of Chemical Theory." (Trans. by Henry Watts). 1869.

TORONTO
January, 1911

A. SINCLAIR,
Librarian

LIST OF LANTERN SLIDES

Solar Subjects

A 72 Photo of Sun taken at Quebec Observatory August 28, 1870.

73 Solar Eclipse August 30, 1905, Corona, from drawings by eight priests, at Burgos, Spain, by Spee.

74 Solar Eclipse.

75 The Sun, July 18, 1905, showing spots, by E. W. Maunder, Greenwich.

76 Composite drawing of Eclipse of August 30, 1905, taken at Daroca, Spain.

77 Photos of Solar granulations (Hansky).

78 Photos of Solar granulations (Hansky). June 25, 1905.

79 Photos of Iron flocculi low level calcium flocculi, and hydrogen flocculi.

80 High and low level calcium flocculi (Mount Wilson).

81 Series obtained on August 25, 1904.

82 The Sun with sun spots and faculæ, September 4, 1893.

83 Great protuberance on east limb of sun, August 30 1905. (Photo by Schorr, Hamburg).

84 Corona, August 30, 1905, by Schorr, of Hamburg, taken in Algeria.

85 Diagram showing transits of Mercury for 20th Century.

86-88 Diagram showing transits of Mercury.

89 Eclipse of January 3, 1908, taken with Floyd lens. Exposure 4s.

90 Eclipse of January 3, 1908, taken with 40 ft. Camera. Exposure 16s.

91 Eclipse of January 3, 1908, taken with 40 ft. Camera. Exposure 32s.

92 Eclipse of January 3, 1908, taken with Floyd lens. Exposure 64s.

The above four slides are from negatives of the Lick Observatory, taken by the L. O. Crocker Expedition to Flint Island.

93 Sun Spot and Hydrogen Flocculi, June 3 and 4, 1908.

94 Sun Spot and Hydrogen Flocculi, June 3, 1908.

95 Sun Spot and Hydrogen Flocculi, May 20 and June 2, 1908.

96 Prominences at eastern limb of Sun, April 3 and May 26, 1908.

97 Sun Spot, December 2, 1908, at 7 a.m. and December 8, 1908, 9.15 a.m. Drawings by Prof. Leon, Mexico.

A 98 Group of Sun Spots December 18, 1908, 8 a.m. Drawing by Prof. and Mrs. Leon.
99 Group of Sun Spots, December 19, 1908. Drawing by Prof. Leon, Mexico.
100 Sun Spots, December 29, 30, 31, January 29, 1909. Drawings by Prof. Leon, Mexico.

Stellar Subjects

B 79 Great Nebula in Andromeda.
80 Map of Southern Constellations.
81 Chart of Southern Constellations.
82 Great Photographic Nebula near π Scorpii.
83-86 Charts showing Stellar Magnitude.
87 Hercules Cluster.
88 Crab Nebula.
89 Planetary Nebula.
90 Nebula N. G. C., 2237-9 Monocerotis.
91 Dumb bell Nebula, from a drawing.
94 Chart showing distribution of double stars by magnitude. (Burnham).

Lunar Subjects

C 94 Copernicus and surroundings.
95 Map of Moon by Edward Elgar.
96 Triesnecker from cast.
97 Photo of Moon by K. M. Clipsham, with 10-inch reflector, January 2, 1906.
98 Photo of Moon by K. M. Clipsham, with 10-inch reflector, January 6, 1906.
99 The Moon at 1st and 3rd quarter showing librations. Lick photo.
100 Photo of Plaster Cast of Lunar Crater Triesnecker by N. and C.
101-106 Partial Eclipse of Moon, July 24, 1907. From photos taken at six different stages by Rev. D. B. Marsh and presented by himself.
107 Portion of the Moon's surface shown at sunrise and sunset.
108 Tycho and its surroundings from plaster cast by N. and C.
109 Gassendi from plaster cast by N. and C.
110 Theophilus, Cyrillus and Catharina from plaster cast by N. and C.
111 Ptolemy, Alphonse, Arzachæl, etc., from plaster cast by N. and C.
112 Plato from plaster cast by N. and C.
113 Lunar Apennines, Archimedes, etc., from plaster cast by N. and C.
114 Full Moon, map colored.

C 115 Full Moon, from plaster cast by N. and C.
116 Drawings of the Crater Abulfed showing changes.
117 Drawings of the Crater Messier showing changes.
118 Drawings of the Crater Censorinus showing changes.
119 Drawings of the Crater Franklin showing changes.
120 Drawings of the Crater Plato showing changes in cones.
121 Aristarchus and Herodotus from plaster casts.
122 Normal lunar Crater from plaster cast.
123 Map of the Moon.
124 Full Moon from plaster cast.
125 Photo showing occultation of Mars by the Moon, September 1, 1909, 9.55 p.m. Presented by Dr. D. B. Marsh.
126 Cracked glass globe to illustrate rays from Tycho.

Planets

D 43 Two views of Mars from drawings.
44 Orbits of the Earth and Mars.
45 Sketches of Mars by S. I. Bailey and W. H. Pickering.
46 Sketches of Mars by S. I. Bailey and W. H. Pickering.
47 Sketches of Mars by E. E. Barnard and Philip Fox.
48 Sketches of Jupiter, August 18, 1902.
49 Sketches of Jupiter, June-July, 1902.
50 Sketches of Jupiter, August 15, 1902.
51 Diagram to explain the apparent looped paths of Mars and other planets.
52 Diagram showing relative distances and sizes of the sun and planets.
53 Series of photos of Jupiter taken on April 26-27, 1909, by Lowell.
54 Series of photos of Jupiter taken on April 27, May 11, 1909, by Lowell.
55 The Heavens according to Ptolemy.
56 Series of photos of Jupiter taken on April 26-27, by Lowell.

Comets

E 18 Path of Halley's Comet.
19 Orbit of Halley's Comet.
20 Photos of Daniels Comet of 1907, at various dates, (L. O.).
21 Photos of Daniels Comet of 1907, at various dates, (L. O.)
22 Halley's Comet February 3, 1910, and Comet *a* 1910, January 21, Photos by Barnard, Bruce Telescope, Yerkes Observatory.
23 Comet Morehouse, October 16 and 19, 1909.
24 Comet Morehouse, October 31 and November 1, 1909.
25 Comet Morehouse, November 18 and 26, 1909.
(Nos. 23-25, from photos by Motherwell at the Dominion Observatory.)
26 Comet Morehouse, October 15 and November 15, 1908.

E 27 Halley's Comet, May 1910. Yerkes Observatory.
28 Halley's Comet, May 3, 1910. Dom. Observatory, Ottawa.
28*a* Halley's Comet, May 3, 1910. (Duplicate).
29 Halley's Comet, May 5, 1910. Dom. Observatory, Ottawa.
29*a* Halley's Comet, May 5, 1910. (Duplicate).
44 Diagram of the Orbit of the Earth and the Orbit of Halley's Comet nearest the Earth in 1835 and 1910.
45 Comet of 1860. Six drawings of the head, June 26-July 8.
46-48 Halley's Comet, 1835-6. Various drawings by C. P. Smith, from November 11, 1835 to January 26, 1836.
49 Comet 1910 *a*.
50 Halley's Comet, May 3 and 5, 1910. Dom. Observatory.
51 Halley's Comet, 1910.

Meteorites

E 40 Shelburne Meteorites.
41 Shelburne Meteorites, rear view.
42 Shelburne Meteorites, two stones joined.
43 Shelburne Meteorites, two stones joined, rear view.

Portraits

F 46 Schiaparelli, G. V.
47 Lowell, Prof. P.
48 Pickering, W. H.
49 Halley.

Spectra

G 17 Spectrum of ·0 Ceti December 18^d 14^h 32^m 1906. G.M.T.

Aurora

H 14 Zodical Light at Cape of Good Hope, 1845.

Views

J 25 Collins' Telescope.
26 Micrometer of 40-inch Yerkes Telescope.
27 Lower part of Mount Wilson trail showing pack animals loaded with lumber.
28 Truck for hauling heavy instruments on Mt. Wilson trail.
29 House for Snow Telescope on Mt. Wilson.
30 House for Snow Telescope on Mt. Wilson.
31 Concave mirror of Snow Telescope.
32 The five foot spectro-heliograph when under construction.
33 The five foot spectro-heliograph mounted for use with the Snow Telescope.
34 Spectroscopic Laboratory of the Solar Observatory.
35 Micrometer eyepiece. Ottawa Observatory.
36 Cartoon from *Punch*, 1906. "Discovery of a Comet at Greenwich Observatory."
37 American Cartoon on the re-appearance of Halley's Comet.
38 Illustration of Medal struck in Germany to allay the terror caused by the Comet of 1860.

Miscellaneous

K 45 Diagram showing Heaven, the Earth and the Abyss according to the writers of the Old Testament.
46 Diagram showing Sun, Moon, Venus and the Host of Heaven, on a Babylonian Monument of the 12th Century, B.C.
47 Table showing texts from Old Testament referring to Constellations, showing different readings, Job ix. 9.
48 Table showing texts from Old Testament referring to Constellations, showing different readings, Job xxxvii. 9, Amos v. 8.
49 Table showing texts from Old Testament referring to Constellations, showing different readings, Job xxxviii. 31, 32.
50 Dalton's table of Atomic Weights.
51 Earthquake records of April 18, 1906, registered at Lick Observatory.
52 Earthquake records of April 18, 1906, registered at Lick Observatory.
53 Diamond Head, Hawaii
54 Interior of Haleakala, Lava Cone, Hawaii.
55 Bullialdus, Kies and Mercator.
56 Crater Pit, Kanhaku, Hawaii.
57 The Lava Lake in Kilauea, Hawaii.
58 Craterlets, Kilauea, Iki, Mokuaweoweo.
59 Spiracles, Kilauea, Part of Crater Bowl, Hawaii.
60 Crater, Kilauea, Hawaii.
61 Erosion Valley Tantalus Oaku, Theophilus, Eratosthenes.
62 Diagram—Crater Sections.
63 Slag Crater—By Brashear.
64 Diagram showing position of stations for observation of variations of latitude.
65 Diagram showing variation of latitude 1890-1895.
66 Diagram showing variation of latitude 1895-1900.
67 Diagram showing variation of latitude 1900-1905.
68 Aparatus for detecting Radio-activity.
69 Aparatus for detecting Radio-activity.
70 Diagram of Radium discharges.
71 X-Ray print.
72 Radio active electrical discharges.
73 Photo of Great Nebula in Andromeda using Radium as a source of light; also Spectrum of Radium Bromide.
74 Photo of Lightning Flash, July 24, 1908, New Zealand.
75 Photo of Lightning Flash, June 6, 1896, at Toronto.
76 Map of Alaskan Series of Volcanoes.
77 Map of Central and South American Volcanic Areas.

K 78 Asiatic Series of Volcanoes.
79 Crater of Vesuvius.
80-83 Series of Slides showing various sectional diagrams of Craters, from Nasmyth and Carpenter.
84 Diagram showing rupture of crust. N. and C.
85 Photo of Clouds.
86 The Zodiac of Denderah.

Labrador Eclipse Expedition, 1905

L 1-3 Views near Quebec.
4 Map illustrating trip to Labrador.
5 Map illustrating track of Eclipse through Canada.
6, 7 Str. King Edward ; and loading cargo
8-20 Views on River and Gulf of St. Lawrence.
21-27 Views of Icebergs.
28-34 Incidents on board ship.
35-42 Views about Northwest River.
43-77 Apparatus and installations in Eclipse Camp.
78-89 Incidents and views about the Camp.
90-91 Photographs taken during totality.
92-99 Incidents of return trip.
100 Dominion Observatory, Ottawa.

M 1-74 Sir Ernest Shackleton's Expedition to South Pole. (Photographs by W. A. R. Michell).

The above is a Supplementary List of Lantern Slides to the Original List which was published as an appendix to the *Transactions* for 1904.

The Society's Slides are loaned to members on condition that the borrower pays all transportation charges, is responsible for breakages and undertakes to return them immediately after the occasion for which they were borrowed.

For further information apply to

R. S. DUNCAN, *Curator*
64 St. George St., Toronto

INDEX TO VOLUME IV.

* Indicates Book Reviews

A

*Arrhenius, S., Life in the Universe, 65.

Art and Astronomy, *John A. Paterson*, 282.

Astronomical and Astrophysical Society of America, *J. S. Plaskett*, 373.

Astronomical Notes, 66, 154, 234, 309, 409, 489.

Astronomy and Astrophysics, Recent Researches in, *W. Balfour Musson*, 1.

Astronomy and the Bible, Rev. Canon Howitt, 220.

Astronomy of Precision in the Southern Hemisphere, 155.

Astrophysics, Notes on, *J. S. P.*, 53, 143, 300, 394.

Auroræ, Photographs of, 309.

B

Barcelona Astronomical Society, *C. A. Chant*, 496.

Barr, J. Miller, Binary Stars, 261.

*Belot, E., L'Origine Dualiste des Mondes, 488.

Binaries, Spectroscopic, Dominion Observatory, *J. S. P.* 53, 394.

Binary Stars, *J. Miller Barr*, 261.

Binary Stars, ε Ursæ Minoris, *J. S. Plaskett*, 460.

*Bosler, J., Les Théories Modernes du Soleil, 407.

Bruce's Observatory, Hamilton, *C. A. C.*

C

Campbell, W. W., Some Preliminary Results Deduced from Observed Radial Velocities of Stars, 353. Water Vapor on Mars, 212.

Cannon, J. B., Elements of 93 Leonis, 452; Orbit of φ Persei, 195.

Capture Theory, Prof. See, *C. A. C.*, 318.

Chant, C. A., Halley's Comet, 104; Johann Gottfried Galle, 379; Mount Wilson Conference of the Solar Union, 356; Sir Wm. Huggins, 253.

Comet, 1910*a*, R. M. Motherwell, 55; Discovery of, Denning, 490; Halley's, R. M. Motherwell, 54-55; Halley's, C. A. Chant, 104.

D

Determination of the Constitution and Radial Motion of the Stars, *J. S. Plaskett*, 135.

Distances of Red Stars, Russell, 490.

Dominion Observatory, New Photographic Lens, *J. S. P.*, 143.

Double Star Measures, *R. M. Motherwell*, 447.

α Draconis, a Least Square Solution of the Orbital Elements of, *W. F. Harper*, 91.

*Dupuis, N. F. Elements of Astronomy, 488.

E

Earthquake Epicentres, *Otto Klotz*, 173.

Earthquake Notes, *O. K.*, 158.

Earthquake Records, Dominion Observatory, 56, 116, 145, 225, 302, 396, 482.

Earthquake Records, Toronto and Victoria, *J. V.*, 58, 153, 233, 308, 406, 487.

* Elements of Astronomy, for Engineering Students, N. F. Dupuis, 488.

Elements of 93 Leonis, *J. B. Cannon*, 452.

F

Flexure in the Axis of a Meridian Circle, *R. M. Stewart*, 132.

G

Galle, Johann Gottfried, *C. A. Chant*, 379.

Geodetic Base Lines, Measurement of, with Invar Tapes and Wires, P. A. Carson, 217.

Gyroscope and Gyroscopic Action, W. F. King, 42.

H

Halley's Comet, A. D. Watson, 236; *C. A. Chant*, 104; A Layman's Diary of, 1910, *A. F. Hunter*, 204; Dominion Observatory, 143, 224, 300; Ephemeris of, 160; Transit of, aud passage of earth through tail, *C. A. C.*, 238.

Harper, W. E., A Least Square Solution of the Elements of α Draconis, 91; Orbit of η Boötis, 191.

Huggins, Sir Wm., *C. A. Chant*, 253.

Hunter, A. F., A Layman's Diary of Halley's Comet, 1910, 204.

J

Jupiter, Photographs of, Percival Lowell, 81; Markings on, S. B., 493.

K

Klotz, Otto, Earthquake Epicentres, 173; Earthquake Notes, 158; Scientific Crumbs from Europe, 21; The Seismograph, 116.

Knots on Saturn's Rings, A. Elvins, 317; M. J., 492.

L

Lantern Slide List, appendix, 32.

Latitude Determination by Astronomy, 43.

Least Square Solution of the Orbital Elements of α Draconis, *W. E. Harper*, 91.

* Les Théories Modernes du Soleil, Par J. Bosler, 407.

Library Catalogue, appendix.

Lick Observatory, C. A. Chant, 412.

* Life of the Universe: as conceived by man from the earliest ages to the present time, Svante Arrhenius, 65.

Light Pressure, 311.

Location of the Pole, *L. B. Stewart*, 179.

*L'Origine Dualiste des Mondes, Par E. Belot, 488.

Lowell, Percival, Photographs of Jupiter, 81.

Lunar Features, The Genesis of Various, 309.

M

Magnetic Observations at Agincourt, 64, 148, 229, 402, 486.

Magnetic Observations, Dominion Observatory, 146, 227, 304. 395, 480.

Magnetic Results, *Otto Klotz*, 146.

Mars, Lowell Observatory, 234; Notes on, 157, 237, 415; Water Vapor on, W. W. Campbell, 212, 237.

Maybee, J. E., Stellar Magnitudes, 345.

Meetings of the Society, at Toronto, 35. 130, 214, 386, 466; at Ottawa, 42, 132, 215, 388, 469; at Hamilton, 49, 137, 219, 299, 390, 471; at Peterborough, 48, 141, 473; at Regina, 391; at Winnipeg, 478.

Meridian Work, Dominion Observatory, R. M. Stewart, 144, 222.

Meteoric Shower, Perseid, 1910, 312.

Meteorology in Japan, T. O., 492.

Mirrors, Protection of, M. A. Perot, 70.

Modified Method for Nadir Observations, *R. M. Stewart*, 267.

Moon, Variations in, Goodacre, 491.

Motherwell, R. M., Double Star Measures, 447.

Mount Wilson Conference of the Solar Union, *C. A. Chant*, 356; Notes on Travel to, *C. A. C.*, 410.

Musson, W. Balfour, Recent Discussion in Astronomy and Astrophysics, 1.

N

Nadir Observations, Modified Method for, *R. M. Stewart*, 267.

Nebula, Spiral, M.51 (Canum Venaticorum) 314.

Nebulæ, Spiral, (Ritchey), 310.

Newspaper Astronomy, *C. A. C.*, 495.

Notes and Queries, 159, 237, 317, 410, 494.

Notes from the Dominion Observatory, 53, 143, 222, 300, 394, 480.

Notes from the Meteorological Service, 59, 148, 229, 305, 400, 483.

O

Observation of Faint Stars, Barnard, 70.

Olbers: the greatest of Amateur Astronomers, *A. D. Watson*, 271.

Orbit of ε Herculis, Correction for, 301.

Orbit of η Boötis, *W. E. Harper*, 191.

Orbit of φ Persei, *J. B. Cannon*, 195.

Origin of the Solar System, Prof. See, 155.

Otto Klotz, Earthquake Epicentres, 173.

Our Earth in the Universe, *Otto Klotz*, 427.

P

Paterson, John A., Art and Astronomy, 282.

Personality with the Transit Micrometer, *R. M. Stewart*, 94.

Photographs of Jupiter, Percival Lowell, 81.

Plaskett, J. S., Astronomical and Astrophysical Society of America, 373; Slit Widths and Errors of Measurements in Radial Velocity Determinations, 333; The Spectroscopic Binary ε Ursæ Minoris, 460.

Predictions, 71, 166, 244, 321, 417, 497.

Presentation to Society, Hon. J. R. Stratton. 473.

*Principles and Methods of Geometrical Optics, especially as applied to the theory of optical instruments, Jas. P. C. Southall, 407.

R

Radial Velocity Determination, *J. S. Plaskett*, 333.

Radial Velocities of Stars, Some Preliminary Results Deduced from Observed, *W. W. Campbell*, 353.

Radiation and Absorption, (Humphreys) 235.

Recent Researches in the Structure of the Universe, (Kapteyn) 68.

S

Satellites of Mars, Brightness of, R. G. Aitken, 66.

Scientific Crumbs from Europe, *Otto Klotz*, 21.

Seismograph, The, Otto Klotz, 56, 116, 145, 225, 302, 396, 482.

Sir Wm. Huggins, *C. A. Chant*, 253.

*Southall, Jas. P. C., Principles and Methods of Geometrical Optics, 407.

Spectra of Comets, A. Fowler, 157.

Spectroscopic Binaries, Dominion Observatory, *J. S. P.*, 394.

Spectroscopic Binary, φ Persei, *J. S. Plaskett*, 53.

Spectroscopic Binary ε Ursæ Minoris *J. S. Plaskett*, 460.

Spectrum of Comet 1908*c*, (Morehouse), H. Rosenberg, 154.

Slit Widths and Errors of Measurements in Radial Velocity Determinations, *J. S. Plaskett*, 333.

Solar Radiation, Abbot, Schuster, 489.

Solar Union, Mount Wilson Conference of, *C. A. Chant*, 356.

Solar Vortices and Magnetism of Sunspots, C. G. Abbot, 66.

Stars, Classification of, W. B. M., 471.

Star Swarms, H. H. Turner, 70.

Stellar Magnitudes, *J. E. Maybee*, 345.

Stellar Motions, (Boss and Turner) 315.

Stewart, L. B., The Location of the Pole, 179.

Stewart, R. M., Meridian Work, 144, 222; Modified Method for Nadir Observations, 267; Personality with the Transit Micrometer, 94.

Sunspot Spectra, Hale, 489.

T

Temperature Tables, 63, 151, 231, 306, 401, 485.

Tidal Observations, Darwin, 492.

Topography, How the Camera is applied for, J. J. McArthur, 46.

Transit Micrometer. Personality with, *R. M. Stewart*, 94.

Travel, Notes on, *C. A. C.*, 410.

V

Velocity Curve, Irregularities in, of Some Stars, *W. E. Harper*, 469.

W

Water Vapor on Mars, *W. W. Campbell*, 212; 157, 237, 415.

Watson, A. D., Olbers: the Greatest of Amateur Astronomers, 271.